THE J. PAUL GETTY MUSEUM LIBRARY

Roger Smith on

Schools

p. 771

Digitized by the Internet Archive
in 2017 with funding from
Getty Research Institute

https://archive.org/details/papersreadatroya1873roya

PAPERS

READ AT THE

Royal Institute of British Architects.

SESSION 1873-74.

USUI CIVIUM, DECORI URBIUM.

LONDON:
PUBLISHED AT THE ROOMS OF THE INSTITUTE, 9, CONDUIT STREET, HANOVER SQUARE, W.

1874.

[ENTERED AT STATIONERS' HALL.]

The right of Reproduction and Translation is reserved by the Council.

Dryden Press: J. Davy & Sons, 137, Long Acre, London.

THE J. PAUL GETTY CENTER
LIBRARY

TABLE OF CONTENTS.

TITLE.	AUTHOR.	DATE.	PAGE.
Opening Address	By Sir G. Gilbert Scott, R.A., President.	Nov. 3rd, 1873	1 — 13
On the Mediæval Brickwork of Pomerania.	By J. Tavenor Perry, Associate.	Nov. 17th, „	15 — 31
The Architecture of China	By William Simpson, F.R.G.S.	Dec. 1st, „	33 — 50
Presentation of Sir Charles Barry's Bust.	....	Dec. 15th, „	51 — 53
On the Chateau of Pierrefonds and its Restoration by M. Viollet-Le-Duc.	By R. Phené Spiers, Associate.	Dec. 15th, „	54 — 65
Some of the Sanitary Aspects of House Construction.	By Capt. Douglas Galton, C.B., F.R.S.	Jan. 12th, 1874	67 — 85
On Water Supply for Country Mansions.	By R. B. Grantham, Esq., M. Inst. C.E., F.G.S.	Jan. 26th, „	87 — 97
On the Introduction and Use of the Steam Jet, for cleaning the stone of Hanover Church, Regent Street.	By Edward C. Robins, Fellow.	Jan. 26th, „	98 — 101
On Delong & Co.'s Patent Steam-sawn Metal Work, as applied to Architectural Decoration.	By C. H. Cooke, Fellow.	Jan. 26th, „	101 — 102
On the Central Dome of the Vienna Exhibition Building.	By J. Scott Russell, Esq., F.R.S.	Feb. 19th, „	103 — 125
Discussion on Mr. Scott Russell's Paper.	....	Feb. 23rd, „	127 — 140
On Government Architecture in Bengal .	By Wm. H. White, Fellow.	Mar. 23rd, „	141 — 156

TITLE.	AUTHOR.	DATE.	PAGE.
On the Old Hall and New Assize Courts at Winchester.	By T. H. Wyatt, Fellow.	Apl. 20th, 1874	157 — 169
On Town and Country Schools	By T. Roger Smith, Fellow.	May 18th, „	171 — 185
On Vaulting. With Appendix	By T. H. Eagles, B.A., Associate.	June 1st, „	187 — 208
Memoirs of Deceased Members . . .	....	....	209 — 218
Mediæval Brick Buildings in the North-east of Germany, and on the Coast of the Baltic—(*re-printed by order of the Council*).	By Charles Fowler, jun.	Feb. 18th, 1850	*a* 1 — 6

Royal Institute of British Architects.

SESSION 1873-4.

At the Opening Meeting of the Institute, held on Monday, the 3rd of November, 1873, Horace Jones, Vice-President, in the Chair, the following Paper was read:—

ADDRESS OF THE PRESIDENT,

Sir Gilbert Scott, R.A.

Gentlemen,—It is with unfeigned regret that I have to ask your kind forbearance with me, in my failure to appear in my place, as your President, at the opening of the first Session after you have done me the great honour of electing me to that office. Previously to that event I had had some idea of spending a part of this autumn and winter at Rome; and had mentioned it to my predecessor when he announced to me the kind wishes of the Council. I had, however, wholly relinquished this idea, and was preparing to return from a continental tour, when I was so urgently pressed by friends, whose opinion I had every reason to respect, to prolong my absence with a view to confirming the good effects upon my health, of the rest and relaxation in which I was indulging, that I felt I should be doing wrong to resist their remonstrances; and I have now to throw myself upon your kind indulgence, and to beg you to allow my inaugural address to be read *for me,* instead of being delivered, as it ought to be, by myself.

My regret at this is increased, and my apologies rendered the more needful, by the fact of my absence rendering it impossible for me to deal with some subjects I am bound to allude to with that care and fulness of information which I should have aimed at had I been present. These subjects, unfortunately, are amongst the most important topics for the year; as, for instance, the transactions of the Institute during the past Session, the papers read at its meetings, the public occurrences relating to our profession, the more important works undertaken or completed, the Great International Exhibition at Vienna, as viewed in its bearings upon our art, and the melancholy duty of chronicling the annual obituary of members of our Institute, and of giving a sketch of the career of the deceased. On all these points my notices must be more or less defective.

On the last named point, I will venture on asking the aid of members of the Institute best acquainted with those whom we have lost, as there would be an appearance of partiality and inequality were I to attempt to record the merits of those I happen to have best known, to the neglect of those with whom I chanced to be less acquainted. Nor would it be proper to attempt a notice of the professional lives of those whose position was prominent enough to demand a special memoir, as is clearly the case with our lamented past President Sir William Tite, whose merits have already been frequently brought before the notice of our meetings, with that respectful warmth of feeling which delights to celebrate even facts the best known and acknowledged; and they will, I feel convinced, be shortly laid before us in a more formal manner and one more proportioned to their public importance. I leave, then, this melancholy though grateful task, to such hands as may be fitly selected to perform it.

Our obituary for the past Session is, unhappily, a very long one. It is as follows:

Sir William Tite, M.P., Past President.
Mr. R. R. Banks, Fellow.
Mr. R. P. Browne, Fellow.
Mr. W. Slater, Fellow.
Mr. A. S. Newman, Fellow.
Mr. J. H. Stevens, Fellow.
Mr. S. S. Teulon, Fellow.
Mr. A. Gilbert, Fellow.
Mr. H. Williams, Fellow.
Mr. C. Buckeridge, Associate.
Mr. G. T. Randall, Associate.
Mr. E. A. Spurr, Associate.
Mr. W. Corbett, Associate.
Mr. J. D. Simon, Associate.

To these I must add our respected Honorary Members Mr. G. L. Taylor, and Mr. Henry Shaw, F.A.S.

And our Honorary Corresponding Members:

Mons. N. De Caumont, of Caen.
Professor F. N. Hessemer, of Frankfort-on-the-Maine; and
Il. Cav. Niccolo Matas, of Florence.

Those best known to me in the sad catalogue were Mr. Teulon, Mr. Slater, and Mr. Buckeridge; the first as a zealous and successful follower of the Gothic revival, and the designer of numerous churches, &c.; the second as the successor of the lamented Mr. Carpenter. He having been cut off in the midst of his days, left his extensive practice, and the professional training of his young son to the care of his faithful pupil and assistant Mr. Slater, who *right loyally* performed the task thus bequeathed him; keeping up the practice, largely as I believe, for the benefit of his friend's family, and carrying on the professional education of the son, till he was of an age to unite with him in partnership; and only living long enough to see him fairly and successfully launched as the successor, through this faithful and efficient medium, of his talented and lamented father. Mr. Buckeridge was a pupil of my own, and was carrying on his practice with great devotion, talent and success, when cut off at an early age by a sudden illness. I hope that further notices of these, and other members of our Institute, will be laid before you by those who have facts better within reach, than is at this moment (unfortunately) the case with myself.

The International Exhibition at Vienna, in its bearings upon architectural art, is another subject on which I must beg the kind aid of such as have given the most attention to it; circumstances having wholly deprived me of the opportunity of making myself acquainted with it, as I feel that I ought to have done. Of public transactions bearing upon our profession I may say much the same.

I much more regret that I am not able, as I had hoped, on the present occasion to notice the works of architecture now about to be commenced, or those recently finished. I had promised myself much pleasure in the performance of this part of my duties; but my necessitated absence during the summer has rendered it impossible, and I must beg to reserve it for a future occasion, should such offer. It would to me be a most grateful task, both to visit the many admirable buildings which have recently been completed, or are in the course of erection, in a more careful and systematic manner than one would perhaps venture upon under other circumstances, and to record the just praises of their architects;

and it would on the present occasion have been the more gratifying, because, in the remarks I shall have to offer, I shall feel it my duty to call attention, not indeed to the demerits of any specific works, for that would be an offensive and a presumptuous act, (and indeed I rarely enquire the name of the architect of any work I should be disposed to censure), but to the general fact of the immense gulf which intervenes in our day between different works, and to ask your special attention to this, as one of the most serious questions before us. Having, then, a painful duty to perform of this nature, it would have been a relief to have enumerated, and lovingly dwelt upon, some of the most admirable works of our period, works which would have done credit to any age in either of the great branches of our art, and works which tend to establish one most encouraging fact beyond the reach of question, that if we live at a time when much is done which tends to discourage, we also have the happiness to live at a time when works of the most contrary class are produced—works of the noblest aim—of the deepest and most loving study and care, and of the highest artistic character. I must, however, of necessity relinquish or postpone this delightful task.

Of public buildings about to be undertaken I will mention one only. I will content myself with congratulating the Institute that the great work of their talented member Mr. Street is, after so long delay, about to be commenced. I regret to observe the statement in the public papers to the effect that a considerable amount is to be struck off from its embellishments. I have not seen the drawings beyond such as have been laid before the public; but from them I should have judged that the architect had already exercised great reserve in this respect; and I fear that a further pruning down, such as is suggested by the sum named, will of necessity have a very serious effect upon the design; and I earnestly, though respectfully, urge upon the attention of the Government the importance of reconsidering this instruction, inasmuch as an amount which sounds like a small per centage upon the entire cost of a building, must bear a very serious proportion to the cost of its mere embellishments, and may go so far as to reduce them to the very verge of poverty.

This is a building of which too much has been said—which has been far too prominently before the public—not only of this country, but of the whole civilized world, to permit of its perfection being tempered with to save some paltry per centage. Such a result would be a disgrace to our age and country, which have a right to demand from those in power, that the architect entrusted with such an edifice shall not have his hands thus cruelly bound, but shall be allowed to embark upon this great national—this great European work with a fair and reasonable amount of liberty, to render it worthy of its origin and destination; while the fierce attacks to which it has been subjected would call forth, even from their originators, if actuated by a true English love of fair play, the demand that the architect should not be unduly restrained, but should have every reasonable opportunity and facility allowed him for the production of a truly noble work, worthy at once of his own fame and of the age and country which the building will represent.

I will now proceed to the affairs of our Institute.

The Annual Report, which has been for some months in your hands, together with the lately issued conspectus of the proceedings at the Ordinary and at other General Meetings, will give a correct idea of what has been done during the last Session, as well as of the general prosperity of the Institute.

From the former document it will be seen that our pecuniary status is well kept up, that our list of members shews a constant increase, that the Institute has been actively engaged on a number of important questions, bearing both upon our professional dignity, and upon the interests of our art; that in the consideration of these questions we have been well met and aided by a Conference of Architects from all parts of the kingdom, from which Conference very useful results are likely to arise; that the architectural examinations of students seeking our diplomas have met with revived and increasing encouragement; that our offers of studentships, prizes, medals, &c., have been responded to not only by satisfactory numbers of candidates, but by a degree of excellence in the competing works of a most encouraging character, while the sketch books of the medallists have shewn a most cheering result. It will also be seen that the standing Committee for the Conservation of ancient Monuments has been working with activity,—in short, that the Institute has been actively and successfully performing its arduous duties. Appended to our new List of Members is a synopsis of the excellent Sessional Papers read at our meetings, together with further particulars as to many subjects which have come under the consideration of the Institute.

The medals, prizes, &c. awarded, have been as follows:—The Soane Medallion (with the sum of £50. under the usual conditions of continental study) to Mr. William Frame, for a design for a public hall; and a Medal of Merit, in the same competition, to Mr. J. H. Eastwood. The Institute Silver Medal, with Five Guineas, to Mr. Alexander H. Kersey, for drawings illustrating St. Mary's Abbey, Old Malton; and Medals of Merit in the same competition to Mr. Thomas Garratt for drawings illustrating St. Mary's Abbey at Lilleshall; and to Mr. Arthur Hill, Associate, for drawings illustrating St. Cormac's Chapel, Cashel. Of the high standard of merit evinced by these several sets of drawings I am able, myself, to speak in the strongest terms. A Medal of Merit has also been awarded to Mr. Alfred Jowers, Associate, for an Essay on Modern Architectural Criticism. The Pugin Travelling Studentship was gained by Mr. Aston Webb.

It was also unanimously resolved, humbly to recommend to her Majesty, that the Royal Gold Medal should be awarded to our late excellent President, Mr. Thomas Henry Wyatt, which recommendation was, as you well know, graciously accepted.

Though the pecuniary condition of the Institute cannot be viewed as other than prosperous, I think that an examination of our annual accounts will be sufficient to afford conviction that our income is not more than sufficient to meet the actual demands of the Institute itself. I cannot, therefore, wholly sympathize with the yearning so often expressed, for a union under our single banner of all the Societies bearing upon our art or profession. Had our income sufficed, or could it be made to suffice for all objects, I should rejoice to see all united, and that our Institute should have the credit of all; but when I see a gift for a most important object in promoting the study of our art only agreed to on an express understanding that the application should not be repeated, and am obliged to acknowledge the conditions, however ungracious it may appear, to have been necessary, I cannot but rejoice that the efforts for our common object take numerous channels, and that no attempt is made at their undue centralization. Let them be bound together by a bond of common sympathy, but let their finances and their management be several, for depend upon it no single list of subscriptions will ever be sufficient to cover the multifarious objects which bear upon an art of such universal application.

Art education, however, is an object of such paramount importance, that in spite of all discouragement, I recommend it to the special attention of the Institute. As to its finances, it ought, I feel convinced, to be in great degree *self supporting*, but it ought to be nevertheless, in a greater or less degree, under the direction of our Institute and of the sister Association. The Royal Academy has of late given greater attention to the subject than formerly, and it has occurred to me that a useful result might arise from a conference between our Institute and that body, though I have not sufficiently matured my thoughts on this subject to enable me to offer any specific suggestions. I will say, however, that I feel very averse to so rigid and straight-laced a system of training as that adopted in France, which seems to me calculated to repel by its slavery rather than to win the warm affections of its students.

It occurs to me, however, that much may be done, both by increasing our library and by adding in every way possible to the facilities for making use of it; and if we have any surplus from our annual income, I would strongly commend that direction as the most profitable for its expenditure.

I will take the liberty of mentioning that two points struck me rather painfully at our professional Dinner last June. The first was this,—that the Chairman of the Metropolitan Board of Works, when alluding to the proposed demolition of Northumberland House, seemed to state that the Board had been encouraged in pressing that project by the opinion of our Institute. Now, I am not well versed in the subject itself, or in our own course with reference to it, but strongly holding, that in all public improvements, it should be made a principle to preserve both existing public monuments, and private buildings which from their importance assume a public character, I trust that I misapprehended what I heard, for though it *may* occasionally become *unavoidable* to deviate from this principle, I should be distressed to think that such deviations should ever be able to claim the authority, or even the connivance, of an Institute, which should be, and is, the protectress of all public monuments.

The other point I allude to is this:—In the annual report of the Institute, I find that in announcing the intention of having a professional dinner, it is stated, that "it will afford an occasion for enlisting subscribers to the charity (the Architects' Benevolent Society) by the same means which are adopted in the case of other benevolent institutions." Now, at that dinner no such means whatever *were* adopted, and had it not been for excellent and almost remonstrant addresses from Mr. I'Anson and Mr. Christian, the subject announced as the special object of the meeting might have been almost forgotten. I take the liberty of alluding to this, for the sake of recalling attention to the subject, and especially to the remarks of Mr. I'Anson and of Mr. Christian: for, with all our professional prosperity, it would ill become us as a representative Institution to forget the claims of our less fortunate brethren.

In reviewing the whole subject of the position of our Institute, I cannot but sincerely and heartily congratulate you on its constantly increasing usefulness, influence and prosperity. Few instances probably can be found even parallel to this, and I earnestly trust that our success may not only be permanent, but may grow at an ever increasing ratio.

While congratulating ourselves, which we have every ground for doing, on the material prosperity of our Institute, on its happy effect as a common ground of reunion, in which the members of our profession meet on equal and friendly terms;—as a means of producing genial feelings amongst them, one towards another, of softening asperities, of rubbing off prejudices and cementing friendships;—as a standard and referee on all questions of professional practice and etiquette, and as the protector of professional honour; and further, as a Society which, by its prizes and medals, encourages and incents to exertion, and at whose meetings instructive and interesting papers are read and discussed, calculated to disseminate the knowledge of matters bearing upon our common art, and the important practical matters which relate to it; while congratulating ourselves, I repeat, with just pride on our success in all these, and many other ways, which it would be too lengthy to enumerate;—let us never, for one moment forget, that such Societies as ours, and others to which allusion has been made, are but instruments to aid in the promotion of the common end and object for which we should all be earnestly labouring:—the raising the great art of Architecture, and of the arts subsidiary to it, to that high level which the civilization and prosperity of our age, and its advancement in science, in literature, and in mechanical art, *imperatively demand. This*, Gentlemen, I need not say is the *real*,—the *ultimate* object, of such Institutions as ours; and towards *this* should all our efforts tend as the one great central object of our earnest aim, and our heartfelt aspirations.

At all great periods of art, so far as we can gather from historical records, or from the internal evidences so abundantly supplied by the actual works which have been spared to us, there can be no room for doubt that the efforts, the enthusiastic strivings, and the whole heart and soul of each artist, from the humblest to the most exalted, were ever directed, as their single object, to the advancement and perfection of the art on which they were engaged.

However different, and even contrary, may be the artistic sentiments expressed by the remains of the great Pharaonic period, of the age of Pericles and Phidias, of the Augustan age at Rome, of the age of Justinian at Constantinople, of the twelfth and thirteenth centuries in North-western Europe, of Arnolfo and Giotto with their host of Mediæval fellow-workers, and finally of that army of painters, sculptors and architects who accompanied what is known as the period of the Renaissance;—works which have defied all their followers to rival, whatever, I say, may be the difference, and even the contrariety, of the artistic sentiments which inspired those almost superhuman productions of art, one fact is common to them all, one golden thread unites them as it were into one:—the fact, I mean, that they are all the works of men who were devoted *heart* and *soul*, absolutely and unreservedly, to their art, and with whom personal advancement, social position, or any other consideration were as dust in the balance when weighed against the perfection of the arts to which they had sworn allegiance.

Until we can resuscitate among ourselves a like glorious enthusiasm, it is vain to hope for another great period in Architecture. True it is, that knowledge and skill are elements necessary to perfection, but neither one nor the other can be acquired without that burning zeal which pervaded the old schools of art, while its presence impels its possessor to their acquirement, and even goes far at times towards compensating for their imperfection. Now, though I do not believe that such chronic enthusiasm can be brought about directly by intention, or by any external means, but rather that it arises from a spontaneous excitement of the human mind, apart from deliberate intention, I do nevertheless think that, if once excited, it may be promoted and cherished, or that it may be damped and even extinguished, by generous encouraging sympathy upon the one hand, or by cold-hearted absence of sympathy on the other.

Let us for a moment enquire whether, in our own day, we have had any promise of such a spontaneous rise of earnest enthusiasm as would suggest the possibility of the advent of a great period in our art. Of individual and enthusiastic zeal we have had much, of which the contemplation is entrancing. Our founder and former President, Professor Donaldson, gave us in his inaugural address a charming sketch of the career of his lamented predecessor, Professor Cockerell, from which—and we have ample evidence besides—we can see that that admirable man possessed all the burning zeal and generous enthusiasm, united with that high artistic sentiment and power, which has characterized the artists of the greatest periods. Our friend's own participation in those noble feelings, were not other proofs so abundant, is sufficiently evinced by the earnestness with which he records them; and that they were shared by many others we have only to look to the artistic lives of Barry, and many others of our architects, who have rendered their memory imperishably great, and who, having arisen during a period of comparative deadness in the art, have laboured earnestly and successfully in instilling into it a new life.

Besides these great men however, we have in our day been witnesses to a movement in our art which, however different may be our estimates of its value, can at least lay claim to the merits of having been at once spontaneous and enthusiastic, of having united in a single aim a greater number of persons, whether professional or otherwise, than any other movement of modern times, and of having, to a greater extent than any other, been *collective* rather than *individual* in its character, sinking in a great degree personal and individual feeling in one great flood of collective ardour. I need hardly say that I refer to the revived feeling for the study and resuscitation of Mediæval architecture.

Many of those among us who, not having personally participated in this movement, view it naturally from the outside, fail to see in it anything but a deliberate effort to overthrow the previously existing state of things, and to erect in its place the creation of a new fashion. For myself, without laying claim to any primary share in this great movement, but being nevertheless a cotemporary of its earliest activity, and having devoted to it an early allegiance, I am able to speak of it, not from the *outside*, but from the *inside;* not as a Laputian critic who, soaring a little above the level of human occurrences, could record them as they passed under his notice without the least personal sympathy in the feelings which gave them birth, but as one within the pale, who has from the first been cognizant of most that has passed, and can speak of it from his own personal consciousness; and in such capacity I am able to assert that the movement has been absolutely spontaneous, and the result of mere love for the study on which it was founded, apart from any hostile feeling towards the *status quo*, and almost free at first from even the thought of disturbing it. If I may speak of my own experience without incurring the charge of egotism, I would say that my own devotion to Gothic architecture began before the thought of my future calling occurred to me; that the choice of my profession arose wholly from that devotion, and that when I subsequently found that my tastes had nothing whatever to do with my practical employments, I still followed them as my almost solitary amusement, with scarcely a thought of their ever becoming the subject of my professional work, which I was for the time passively content should be of necessity in another, and the dominant style.

How this great change came about seems to me as a dream; nor can I clearly recall the manner in which it took place. It seemed to arise spontaneously and unconsciously, the effect of a burning love for the architecture of our forefathers; which, without external cause, without premeditation or concert, had taken possession of the minds of a large number of persons unknown to each other, and only waited its time for practical developement. From such internal causes, what extraordinary effects have arisen! Nothing parallel to either the cause or the effect, has occurred since the Great Italian Renaissance! It has not been our doing; *we* have been the mere humble instruments of a great and unthought of mental movement; and truly its effects are marvellous in our eyes!

I have, thus, alluded to *two* great exhibitions of earnest architectural zeal, which have been manifested in our day:—the one tending to the revival of Classic art from a state of comparative torpor;—the other having brought about the actual resuscitation of the architecture which was indigenous among our own family of nations, and which it has re-established, side by side, and on equal terms with, the long established result of the Classic Renaissance. I am not going over this already well-trodden ground, with any object of partisanship, but simply in search of an answer to my previous enquiry:—*whether in our own day we have had any promise of such a spontaneous rise of earnest enthusiasm, as would suggest the possibility of the advent of a great period in our art;* for, as I said before, until we can resuscitate among ourselves a glorious enthusiasm, like to that which has in former times given rise to the great movements in our art, it is vain to hope for another great period in architecture.

Gentlemen, and brother Architects,—I put the question to you, to which ever of the two great phases in our art you may have vowed your allegiance: *Has* our age been unmarked by such noble enthusiasm? *Have* we lived in days when everything has gone on in its wonted course, unruffled by any special movement, undistinguishable from any other period of equal length in the smooth current of undisturbed art history? The *very reverse*, I boldly assert, has been the case, and the proofs of it are no matters of past and recorded history, but are within the range of our memories; are coincident with the existence of this Institute and are the motive causes of our own daily acts.

Yes:—it has been our own privilege to live during the days of great mental strivings;—of deep and earnest enthusiasm in our art: and though unlike the great periods of old, our art-camp has been divided, and we must be content to work in two parallel courses and in two diverse styles, we have a right,—nay, we are in *duty bound* to ask ourselves, whether we are doing each our duty by the great period of mental up-stirring, in which it has been our lot to be placed: for, I repeat, that such mental movement *may be* promoted and cherished, or that it may be damped and even extinguished by our own conduct towards it.

The first question which suggests itself is:—do *all*, each in his chosen camp, and each according to his ability and opportunities—strive to the utmost to do their work *well*, and to fit themselves for doing it in a manner characteristic of a period of earnest onward striving?

Now, one of the most marked characteristics of the productions of the great periods of Architecture is this:—that, though the works of any one of them differ in artistic merit; some displaying the highest genius, others only comparatively unassuming correctness and propriety, yet no *really bad* architecture is ever to be found among them. From the most majestic and glorious building downward, to the least pretending, the same matured knowledge and the same careful, thoughtful working, is found ever to prevail. Who ever heard of a work of the Greeks at the great period of their art which they would presume to call *bad* architecture? Even in Byzantine art, though it laboured under great disadvantages, we have proofs in the ruined cities discovered in Syria, that buildings of the mere vernacular classes were as carefully studied as the mighty works by which their architecture is better known, while in works of the twelfth and thirteenth centuries in our own and neighbouring lands, as well as in Italy, the same masterly skill, and the same studious handling, is found in the simple village church as in the noblest cathedral—nay, one is often disposed to uncover oneself in humbled reverence before the work of some unheard of mason or carpenter in an obscure village of which we had never before so much as heard the name; nor did these old workmen, so unambitious of fame, ever produce work to the like of which the best or the most self-satisfied among ourselves, need be ashamed to attach his name.

Now,—is such the case among ourselves? It is worse than idle to attempt to blind our eyes by bland felicitations or to seek the bliss of a fool's paradise;—let us rather look facts boldly in the face; and, if they prove unpalatable, let us make it our business to correct them. The true answer to the question is, that no contrast could be more marked than the difference in this respect, between the present state of things amongst ourselves, and that which prevailed at the great eras alluded to. Instead of all works (each in its own style) displaying the same instinctive sentiment, the same understanding of its style of art, the same careful, wise and thoughtful handling,—*the very reverse* of all this is actually the case. From each of our art-camps, productions are put forth of the highest, and of the most contemptible character, as well as of every intervening stage of merit and of demerit. Our age and country will hand down some works of which no age or country need be ashamed, and others at which any age or country, however degraded its art, ought to blush; while I fear a large number of the buildings which will represent our period, are of that negative kind which, being neither hot nor cold, but only lukewarm, will not tend to excite any but a sickly emotion.

Among the works of the Classic school, and more especially among those of a civic and mercantile class, one is, in passing along our streets, often quite startled and taken aback, at the excellence of individual works, while perhaps next door to them one sees others displaying all degrees of want of skill and knowledge, or of ill-instructed and worse effected attempts at originality; while in our provincial towns one often sees perhaps a building rivalling in merit those of the best ages, and others, the Mechanics' Institutes, Corn Exchanges, and such like buildings, the execrable results of those competitions which seem to be inaugurated rather for the amusement of ignorant committees and town councils, than with any wish or aim at adding honour to their towns, by a work of good architecture however unpretending.

In the Mediæval School the same unpleasing fact stares us in the face. On the one hand we may congratulate ourselves that there exists a band of true architects who produce works of a high and some of them of the highest degree of excellence, such as one would fain believe would be acknowledged by the architects of the best age, while on the other hand, we are disgusted by the works of a host of mere pretenders who, wholly unconscious of their ignorance and want of skill, disfigure our towns and our country with buildings, either so utterly contemptible as to be beneath the lowest grade of criticism, or so sickening in their mediocrity, that one wishes they were either cold or hot, as some more pronounced degree of demerit would be almost a relief from their mawkish inanity.

I exclude from my censure upon our two great schools, those works most of which we know, and all of which we may hope, are not the works of architects at all. I refer to the vernacular dwelling-houses which constitute the major part of the buildings of our day. We have recently seen marvellous statements as to the number of dwelling-houses which have, within the present century, been erected in our land. Though, personally, we are for the most part innocent of these, I would put it to our two great schools of architecture, to say what proportion of these are not a disgrace to our age, and a blot upon our towns and our country! The exceptions are happily numerous, and in many cases actually *brilliant*, but they bear no proportion to the immense comprehensiveness of the rule. If the erection of this multitude of houses, instead of being crowded into three quarters of a century, had been extended over five centuries, counting back from the middle of the last, few indeed would have been the number of those with which any very serious fault could be found; and, if we were to concentrate our period a little more, one may almost say that on nearly all one might have looked with some degree of satisfaction. It has been reserved to our own age,—the age of mechanical and scientific progress,—to deluge our land with an inundation of brick and mortar and compo, more degrading in its forms than any previous period has produced! This plague of nearly unmitigated barbarism, is so inveterate that one sees no means by which it can be remedied, except by so absolutely elevating the art produced by members of our own profession, however unpretending their position, as to reflect of necessity its merit upon those of the non-professional builders beneath and around them, and to produce such an atmosphere of tolerable art that it may become impossible for such atrocities to continue to be perpetrated.

There is, however, a yet sadder form of inequality to be recorded,—sadder because irreparable, in the injury it has inflicted. The million of ugly houses, or the evil majority of them, may go to decay, or be rebuilt; but a single ancient edifice destroyed, or ruined, by ignorant "*restoration*," can never be recovered. It is unquestionable that the ancient structures, from the study of which a knowledge of our mediæval styles has been resuscitated, had suffered for the most part so severely from neglect, ill usage, and decay, as to demand the aid of a loving and careful restoration; and this they have happily, in very many instances, received. The knowledge and skill of our neo-mediæval architects has often been devoted with admirable success to this grateful work, and from among the restorations of ancient buildings may be instanced many of the most happy results of the Gothic revival. But here, again, the unhappy diversity I have alluded to, as existing in our new works, is found to exist in its most aggravated form. Our old buildings, too often—nay, in a majority, I fear, of cases—fall into the hands of men who have neither knowledge nor respect for them, while, even amongst those who possess the requisite knowledge, there has too often existed a lack of veneration, a disposition to sit in judgment on the works of their teachers, a rage for alteration to suit some system to which they had pledged themselves in their own works; and even the preposterous idea that the ancient examples they were called upon to repair were a fitting field for the display of their own originality!

Nor have the official guardians of our ancient buildings exercised much restraint upon these vagaries; on the contrary, they have too often been most culpably careless as to the hands to which they have committed their trust, and are usually the inciters to ignorant tampering, the needless removal of valuable features, and even to the condemnation and destruction of the buildings under their charge. The result has been truly disastrous;—so much so, that our country has actually been robbed of a large proportion of its antiquities under the name of "restoration;" and the work of destruction and spoliation still goes on merrily; while, at the public festivities by which each *auto-da-fé* is celebrated, we find ecclesiastical dignitaries, clergy, squires and architects congratulating one another on the success of the latest effort of Vandalism. Our Institute has done itself infinite honour by appointing a Standing Committee to investigate and protest, and by publishing a code of excellent suggestions as to the mode of dealing with ancient remains; but still the work goes on, and the equivocal motto of the *Ecclesiologist*—"*Donec Templa refeceris*"—seems likely to prove well nigh the death-knell of our ecclesiastical antiquities.

I fear I shall be thought to have painted the darker side of our architectural status with greater perspicuity than its brighter side. I do not intend this, for I have a very hopeful appreciation of the happier circumstances of our position: but it is of little use to congratulate each other on our successes, if we fail in courage to confess and denounce our radical failures. I trust, therefore, you will have patience with me if I spend a few moments in suggesting some of the possible causes of the inconsistencies we deplore, leaving to your own consideration the means of removing or abating them.

One might have imagined that there would be no such thing as a really ignorant and thoroughly unskilful or cold-hearted architect; that the spirit-stirring nature of our art would have rendered the existence of such a person impossible; and I am convinced that at the great periods I have so much dwelt upon none such did exist:—but, during a dull period, such as has preceded our own, Architecture came to be viewed by the public as a *profession* rather than as an *art;* as one of the quarters in which a youth could be provided for, rather than as a glorious field for the exercise of mind, imagination and zeal. Just as the Church was viewed by a former generation as an institution providing for sons rather than for saving souls, so has Architecture been dealt with as a *means* of *living* rather than as one of the noblest employments of life; and, in choosing it as a profession, the question has too often been decided by the prospect of a good connection rather than by evidences of any zeal for the art.

It has happily been the case that at all times, however dead, a goodly number of ingenuous youths have allied themselves to our art from the highest motives, and this has of late years so rapidly increased, that I am convinced that it is becoming rather the rule than the exception; yet I cannot but fear that the old leaven of *professionalism* versus *art* has been one cause of the extraordinary contradiction I have been attempting to chronicle. This evil does not *necessitate* ignorance, it is true; but it *induces* it: for though a man, in spite of a non-inclination for art, may study it from a sense of duty and interest, this is hardly expected to go far; and a youth so circumstanced, however conscientious, is far more likely to devote his attention to the more business-like and practical parts of his profession, from which he can most clearly perceive the advantages to be derived, than to those more refined studies, of which he feels perhaps too little appreciation to be conscious of his defects; not to mention that many young men are naturally so little given to application of any kind, that, if they lack the internal fire, they will never bring themselves to that zealous study which is essential to excellence.

A second cause, and perhaps the most damaging of all, is, that the public, as a body, scarcely perceive the difference between good architecture and bad; so that one of the young gentlemen I have alluded to, if he has tolerable introductions and good address, and fair business habits, is really as likely to get on as if he possessed the higher qualifications: nay, I could name many young men of the highest promise who are at this moment *actually languishing* for employment, while others almost innocent of art are making their way prosperously.

This bears directly upon the third cause I would mention—Competitions as now conducted: for what can we hope from them if the judges are known to have no kind of perception as to whether a design is good or bad? Competitions have thus become a mere lottery into which the most ignorant and unskilful may throw his design; and, provided he gives a low estimate and makes his drawings look smart, he knows that "the race will not be to the swift nor the battle to the strong," but time and chance may happen to any; and even if professional or amateur judges be appointed, it may at the best be decided by the fancies of an individual or a clique.

Another—I will not say *cause*, but—*promoter* of this state of things, is the prevailing style of architectural criticism: for, much as our profession is held up to public scorn, one rarely sees a word said against the mere offal of our art, which is the great disgrace of our age: nearly all that appears is levelled against those who have really their hearts engaged in their work, and are enthusiastically aiming at a high standard of art. These are singled out for depreciation, I know not by whom nor with what motives; nor would I care to inquire. Of such critics I would rather say, "O my soul, come not thou into their secrets." Yet, however this may be, it obviously has the effect of encouraging those who employ inefficient architects, and of making the public the more satisfied with their own want of perception.

The next cause, or promoter, of the evil in question to which will I allude, is the want of concert, of mutual sympathy, and of a common aim among the most earnest-minded architects themselves.

I am not alluding to the diversity between the standards of the two great camps into which we have become divided: I doubt whether much harm would come of this, were those who occupy each camp of one heart among themselves. Neither in one, however, nor the other, can this be said to be the case. In neither is one style so prevalent or so paramount as to be clearly the style of the day; in both eclecticism prevails almost to the extent of dissipation. One man has a fad for one shade of style, another for another; and, if common opinion seems for a moment to be settling down into a single channel, this is but a signal for revolt: and in a few years that promised bond of union becomes a mere term of reproach;—the one thing of all others to be scoffed at and rejected. Meanwhile our camps are visited by that great enemy of union and sympathy—self-conceit. I do not refer to that noble self-reliance which gives a man courage for his work, however difficult; but that lower sentiment, which too often makes him intolerant of his fellow-labourer, however true-hearted: and which by means of mutual scorn and depreciation, tends to encourage those whose innocence of art keeps them beyond its range, and warns the careless public against the employment of those who thus bear witness one against another.

I will close my list, by mentioning one of the difficulties of our day, viz.,—the absence of any recognized means of instruction in, or facilities for, the study of the higher branches of architectural art. This difficulty may, it is true, be met and overcome by the zealous; but it affords a practical excuse for the neglect of the study of our profession *as an art* by those who lack enthusiasm. It is the "lion in the way," which is sufficient to deter the apathetic from exertion.

I am conscious that I utterly lack the sagacity to suggest a remedy for all these inherent evils, which seem to drag us back from the goal at which so many are sincerely aiming. I would, however, commend the question to the united wisdom of the Institute, as one of the most important considerations on which it can engage itself.

I beg to apologise for the length to which my address has extended, and for its plainness of speech; which has been so far from being personal, that in my allusions to the defects in some of the architecture of our day, I have in no one instance had a specific architect in view, and feel that I may have myself challenged a *tu quoque*. I now bring my remarks to a conclusion with repeated congratulations, good wishes, personal thanks, and appeals to your kind forbearance.

GEO. GILBERT SCOTT.

The CHAIRMAN,—Gentlemen,—You will probably feel, in the absence of our worthy and excellent President, that less field and opportunity for discussion occurs than if he were present. At the same time there may be many kindly remarks made upon the able Address which we have listened to with so much pleasure, though with, perhaps, a little difference of opinion as to the views expressed on some of the points brought before us. I am sure we shall all be pleased to hear any observations, even though they may be of a critical character, for if critical they may still be friendly, and as such I feel quite confident our excellent President would regard them. We have an eminent amateur and Honorary Fellow amongst us this evening, and perhaps he would like to say a few words upon the subject.

The MARQUIS OF WESTMINSTER, Hon. Fellow,—I am bound, Mr. Chairman, to obey your command; at the same time I feel it is presumptive in an amateur to make any remarks bearing upon architecture, concerning which I can have little claim to speak. I venture, however, to observe that there are one or two points in the able address of my friend Sir Gilbert Scott which are well worthy of attention. One was the emphatic condemnation of those miserable specimens of architecture which unfortunately are to be found in many of our provincial towns. For my part, it seems to me that until the public have acquired more knowledge of the art of architecture, and until that art is more cultivated, discreditable specimens will continue to disgrace our country; I might refer in terms even stronger than those which have been used to the ignorance of the general public, and to the necessity of an artistic education for the young, especially for those who in after life will probably have the means of erecting buildings. I think in that class it is very unfortunate that so little knowledge of architecture exists: I mean in my own class, and those who have the means and opportunities of building in different parts of the country. It occurs to me that this Institute might have the power —and we know it has great influence—to recommend some course of study in the public schools of England; to propose a scheme whereby better knowledge of the principles of architecture might be acquired, and indeed form part of the curriculum of our public schools. You will best judge whether that is a practical suggestion, but it seems to me one which might be of some use, and if this powerful society would use its influence in that direction I think something might come of it. I was talking some little time ago to a man who had arrived at the age of 74 years, and I asked him whether the nave of St. Alban's Abbey was Norman. He replied that he thought most of it was Roman, but that some portion was Norman, because there was a good deal of dog-tooth ornament about it! (Laughter). Now if such ignorance prevails in high places, and in old age, I think the time is come when some endeavour should be made to introduce architectural education in our public schools, in order to give some slight knowledge of this noble art. Apologizing for having detained you with these remarks I will now take the opportunity, which I ought to have done some years ago, of thanking this Institute for having done me the honour of electing me an Honorary Fellow of their body. (Loud cheers.)

Mr. BENJAMIN FERREY, Fellow,—After listening with great pleasure to the able address made to us by our excellent President, I feel that the matter he has brought before us is of so large and vast a character, that it would ill become me to discuss it in detail. I am sure, however, we have all but one feeling upon the subject, and that we all deeply regret his not being present to hear what others might say upon the several points of his address, for in his absence we must refrain, I fear, from making any lengthy comment. I might, perhaps, myself express opinions different in some respects from those which the President has put forward. At the same time we must feel deeply indebted to him, considering the state of his health and the large claims that are made upon him in his professional capacity, for having devoted so much time to an address which so fully dwells upon all points which are interesting to us. I desire, on behalf of the meeting, to express our appreciation of the able address which we have heard; at the same time I would also thank the Marquis of Westminster for the kind manner in which he has spoken on some of the points brought forward. I therefore beg, on behalf of our members, to propose that the thanks of the Institute be given to Sir Gilbert Scott, our President, for his able Address.

The MARQUIS OF WESTMINSTER,—Perhaps I may be allowed to second the vote. I was at Chester when Sir Gilbert Scott was taken so ill a year or two ago, and I went with him to the railway station to see him off. He was then, I am sorry to say, so ill that I scarcely expected to see him again. I am glad he is recovering, and I hope soon to see him amongst us again, and in his place here as your President.

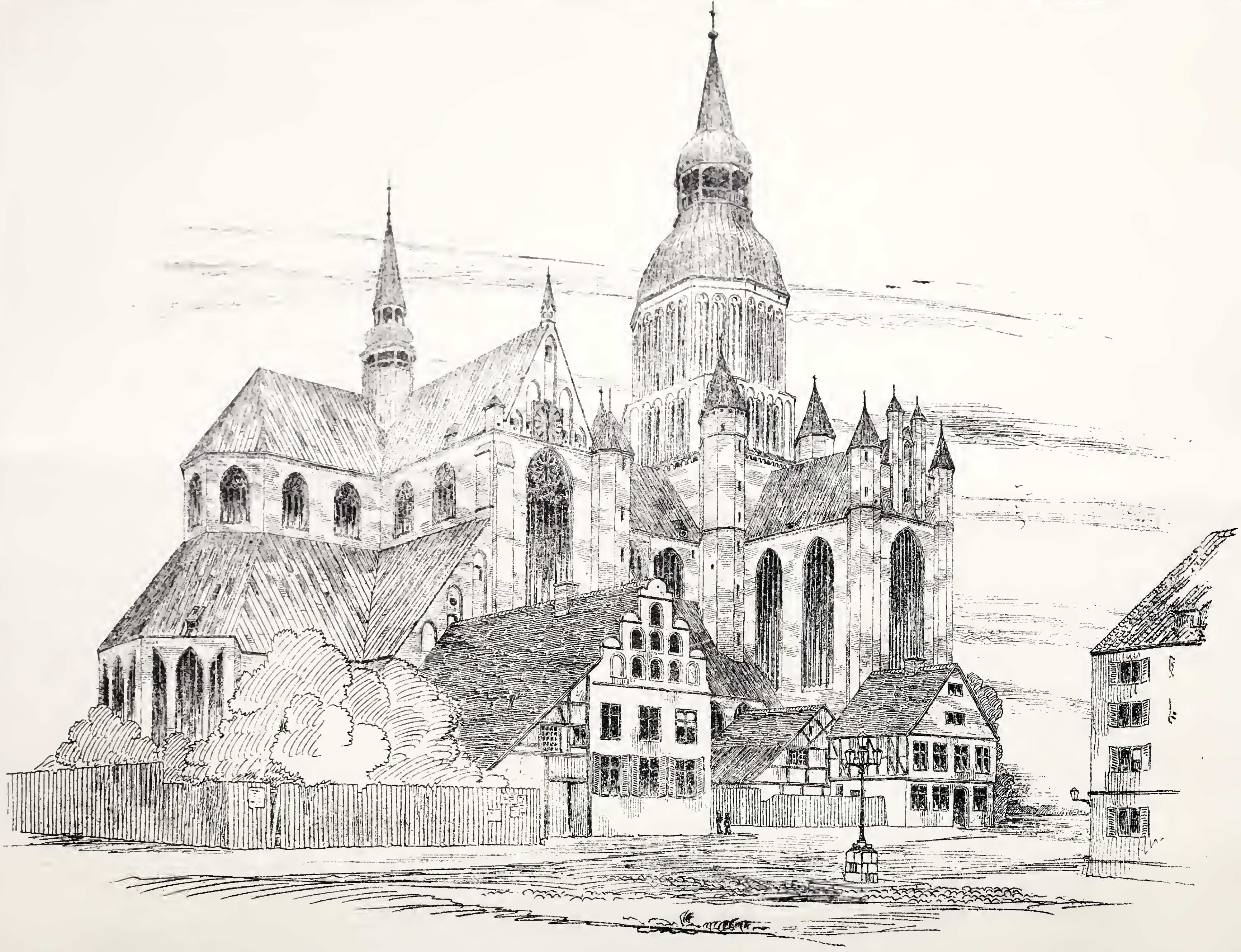
The CHAIRMAN,—I am sure it is not necessary to put to the vote this proposition of our worthy friend Mr. Ferrey; but it will be gratifying to Sir Gilbert Scott, when it is conveyed to him, that it has been proposed by so worthy a fellow-worker and promoter of the very principles of art which he advocates, and that it has been seconded by his personal friend the Marquis of Westminster. We must, I am sure, feel obliged to his lordship for the suggestion he has thrown out to-night with regard to the desirability of architectural education in our public schools, and we must all hope that at some future period the subject will be taken up more earnestly than perhaps it could be at the present moment. With your pleasure, gentlemen, we will record an unanimous vote of thanks to Sir Gilbert Scott for his Address.

The vote having been carried by acclamation,

Mr. EWAN CHRISTIAN, Fellow, said,—I may, perhaps, be allowed to offer a few words with regard to the Architectural Benevolent Society. I am glad to find that our President alludes to the remarks which I made on this subject at our last Annual dinner, because it shews that he takes an interest in the Charity himself. A case has recently been brought before the society in which an architect of real capacity who would, no doubt, if he had lived long enough, have achieved a high reputation in his art—a man who was cut off in the prime of life, leaving a wife and family with scarcely any means to maintain them. He had not lived long enough to make his practice profitable, or to reap the fruits of his early labours. The consequence is that his family are thrown almost entirely on the generosity of strangers. I look upon it as a great reproach to us, as it would be to any benevolent society, that we were only able to give £60. to that family, and yet that was, in point of fact, a large sum for us to give, for the simple reason that our resources are so limited. I may mention that the Artists' Benevolent Society has made some provision for his children. But I regard it as a great reproach to us as architects that a charity specially designed for the relief of our professional brethren is not better supported. It is really discreditable that we should have such a miserable subscription list year after year, and so few donations.

Mr. J. JENNINGS, Fellow,—I cannot allow these remarks to pass without observing that I take a great interest myself in the Artists' Benevolent Society, and the case referred to is one in which that society rendered considerable assistance. I have always thought that in benevolent schemes of this kind artists and architects should combine, inasmuch as artists are to a considerable extent employed to assist architects. I have often thought it a great disadvantage that the two societies are not incorporated in one body, by which means a greater amount of benefit might be secured to the architectural profession, who are in fact represented on the Council of the Artists' Benevolent Society, and who take great interest in its proceedings.

After a few remarks from the Chairman, and some other gentlemen present, the discussion was brought to a close, and the meeting adjourned.



Royal Institute of British Architects.

At the Ordinary General Meeting, held on Monday, the 17th of November, 1873, the following Paper was read, J. Gibson, Vice-President, in the Chair:—

ON THE MEDIÆVAL BRICKWORK OF POMERANIA.

By J. Tavenor Perry, Associate.

When I was asked some time since to prepare a paper on the Mediæval Brickwork of Pomerania and its vicinity, I did not know that the subject was one which had received so little attention from English Architects. Still less was I prepared to find, as I did when I began to look out for the necessary authorities and material, that even in the country of which Pomerania has for so long formed a province, scarcely any work of importance had been published to illustrate the wonderful examples of art and architecture with which it teems. I have, therefore, found some difficulty in my attempt to give you anything like a sufficient account of the peculiar style of work to which I have particularly to draw your attention, and I am sorry to say I have to rely exclusively on my own sketches and notes with a few photographs for any accounts and illustrations of the different buildings I shall have to describe. As these notes were made during two short and very hurried visits, one in mid-winter, I am, sure you will make allowances for the meagreness of many of the details.

One of the earliest published notices to which I can refer you is a Paper by Mr. Charles Fowler in our Transactions for 1850. In the Ecclesiologist and Church Builder there have also been some valuable Papers contributed by Mr. Street, the former containing most careful descriptions of the buildings of Lübeck. Besides these there is also a Paper in the Archæologia for 1863, by Mr. Nesbitt, touching more nearly the provinces I intend to describe to-night. All these notices are brief; but nevertheless they are all the English authorities which I can mention as dealing with this subject; so that these magnificent examples of northern brickwork yet remain to be described with as much care and discrimination as Mr. Street has bestowed upon the similar work in Italy.

German works on this topic are naturally more numerous, and Adler's fine treatise on the Mediæval brickwork of the Prussian States is a valuable assistance to any one reading up the subject. But only small portions of the country are therein dwelt on, the great examples of Pomerania and Mecklenburg being, I believe, unnoticed; so that even in its own country, German brickwork has yet to be properly described.

The meagreness of the information one is able to get relative to the foundation and early history of the Pomeranian towns, is to a great extent to be accounted for by the peculiar character of Pomeranian history. The province was for long periods after the extinction of its native dynasty the object of contention among neighbouring and more powerful states, and by its frequent change of masters it gradually lost all patriotic pride and distinctive character, without the compensation of becoming at the same time a part of any one powerful country. Russians, Poles, Swedes and Danes have at one time or another held parts of it in possession, and it is scarcely more than half a century since it came absolutely into the hands of the kingdom of which it now forms so important a province.

Originally it was peopled by a Wendish tribe, and its natives to this day have a marked difference of appearance to the Germans of the surrounding provinces; whilst in the names borne by many of the towns, and the peculiarities of the low German spoken by the people there are still many marks which distinctly point to this Wendish origin. At the end of the 12th century the Dukes of Pomerania were first recognised as princes of the German empire; and, with the exception of that eastern portion which was wrested from them by the Teutonic knights and eventually added to the Polish crown, the province was governed by its native dynasty down to the commencement of the 15th century.

Through nearly the whole of this period it appears to have enjoyed considerable prosperity, as the important character of the works we shall presently notice will well testify; but with the troubles caused by the Protestant changes in Germany, and the extinction of the native line, this prosperity came to an end. One after another the brothers of the Ducal house died childless: and the last of the race only lived long enough to see the troubles the Thirty years war brought on his unhappy country. The tragic circumstances which led to these misfortunes are admirably detailed by Wilhelm von Meinhold in the account he published of Sidonia von Bork, a lady of high rank and for some time the intended wife of one of the dukes, who in revenge for being disappointed in this, was supposed to have caused the extinction of the whole ducal line by abominable witchcraft.

The physical features of the country, which perhaps more than anything else have modified and influenced the character of its architecture, are peculiar. Through its whole extent it is flat and uninteresting, broken only here and there with low rounded sand hills interspersed with large lakes. The coasts are deeply indented with large gulfs or havens, which form natural harbours, and the country is intersected with broad sluggish rivers, on which in the Middle Ages floated great stores of wealth and merchandise. The land consists of large sandy tracks, with clay below, and through its whole extent no building stone of any sort is to be found. But granite boulders, sometimes of great size, are to be found everywhere deposited by the glaciers and floods, which at one time swept southwards over Europe; and in the country around Stargard they lie to this day thickly spread over the surface in spite of the enormous quantity which has at one time or another been used for building purposes. The greater part of the ground was originally covered with great pine forests, and although these have now to a considerable extent been cleared, and grain grown in their place, large tracks of country are still kept for their cultivation.

Such being its physical peculiarities, it is evident that circumstances were generally unfavourable for building operations. In spite of them, however, towns of great importance filled with churches and buildings of a size and character to challenge comparison with the finest works of Europe, were raised throughout Pomerania; and although the materials used were of the simplest and not unfrequently of the coarsest description, you will see that the results were frequently most pleasing and satisfactory.

The granite was employed for the bases of the buildings, for the town walls, and in some rare instances for the superstructures, but the material almost invariably used for general building purposes was brick. Often of the simplest description and rudest work, sometimes modelled with a delicacy that might rival the finest terra cottas of Italy or carved with the sharpness and boldness of free stone, this brickwork had always an effectiveness and straightforwardness of purpose that leaves little room to regret the absence of the nobler material. When stone was used, which was but rarely the case, it had to be shipped from Sweden, an operation early found too expensive to be often resorted to. The skill with which ornamental features were moulded in clay, caused less desire for carved stone than might otherwise have been felt, and in later examples such features as capitals and bases, which in the earlier buildings were worked in stone, were with the rest of the structure made in brick. The wood with which the country abounded was but little used in the construction of the buildings, and instead of the fine open timber roofs of our own country, we find the churches are almost invariably vaulted in brick; while the love for blank tracery and gables, with the proficiency gradually acquired by their architects in the use of their peculiar material, caused them to prefer the lofty stept brick fronts to the half timber over-hanging stories that were so common in other well-timbered parts of Europe. The roofs of the churches are generally covered with copper, which, turned to a soft green with age, forms an agreeable relief to the red and purple tints of the walls.

I shall confine myself to night to the buildings I have myself visited in the towns of Stralsund, Stettin Stargard, Bergen and Sagard in Rügen, Anclam, Pasewalk, Neubrandenburg and Prenzlau, all of which, with the exception of the last two, are contained in Pomerania itself. Of these, Stralsund is architecturally the most important. It contains six churches of considerable size, a town hall of a remarkable character, some remains of its ancient gates and fortifications, and several houses of a rich and extensive description. Three of the churches are of the first class, being over two hundred feet in length, and of a proportionate height and importance, and they deserve careful notice as each is of a different type and date. The oldest is S. Nicholas, and it is by far the most interesting. It was commenced in 1311, as an inscription still remaining on its west front testifies. On plan it consists of three aisles with chapels between the buttresses, two large towers on the west front, an apse at the east end round which the outer aisle continues, each bay having also an apsidal termination. The whole internal width of the church is about ninety-five feet, while the total internal length is little less than two hundred and fifty feet. It is divided into nine bays exclusive of the western porch and apsidal termination. There is a distinction made between the choir and nave part in the treatment of the lofty piers which support the superstructure. In the former they are richly moulded, and the vaulting ribs brought down the face of the pier, and in the latter case the piers are octagonal with bold angle rolls. The clerestory of the centre aisle is lofty and lit in the choir by large three light lancet windows contained under a single arch, and the aisles have also a clerestory over the side chapels. The piers are of brick except the bases and caps, which are of stone, the bases boldly moulded and the capitals carved with large sharply serrated leaves like those so common in our own late decorated work. The whole of the building is groined in brick with ordinary quadripartite vaulting, and with bold well moulded brick ribs. Large flying buttresses, without pinnacles, support the vault of the nave, while those of the aisles are supported by the deep walls of the outer chapels. The eastern part of the church is only distinguished from the rest by greater richness of the mouldings and piers and a slight break in the roof externally. The west front is particularly imposing. The two towers are carried up square to their full height, without buttresses, and with only a very slight break made by the setting in of each storey over the one below. The treatment is simple in the extreme. Each face of each storey has a series of three blank arches divided into four lights and with a large uncusped circle in the head. These blank windows are, except in height, alike throughout. The stories are divided from each other by long sunk panels over the heads of the arches, which appear to have been designed to receive brick cuspings. The towers seem never to have been surmounted by the spires which were no doubt intended to cover them, but one of them has a picturesque copper dome and flèche of late work.

The Church of S. James's, which appears to have been begun in the latter half of the 14th century, presents a different treatment to S. Nicholas. It has, however, a similar arrangement of three aisles with chapels between the buttresses and is vaulted in brick, but the east end is square and there is only a single western tower. The interior is simple almost to rudeness, the piers are unmoulded, and the arches of the nave arcade are of several orders of plainly chamfered bricks. The richness of the exterior however, makes it the most beautiful church in Stralsund. I very much regret that I am unable to give you drawing of it, but its peculiar position in reference to the surrounding buildings prevented me getting a satisfactory sketch. The square part of the tower consists of three unequal stages, the lowest and largest containing the western entrance and a large six-light traceried window over, and the two stages above having each three large blank traceried windows as at S. Nicholas. The tower is capped by an octagon with a large window on each face and with a bold panelled pinnacle on each angle. The octagon is unfortunately now only finished with a late dome. The whole of the tracery and arcading is filled in with rich brick cusping, which with the ornamental bands and the mouldings of the entrance is very highly glazed.

S. Mary's Church, which is the latest of this group of churches, exceeds the others considerably in size. The details are very poor, and the work generally of a coarse description, but its picturesque grouping and the massiveness of the structure make it altogether a most remarkable church. It consists of three aisles with an apse and ambulatory round, a transept with aisles, a single western tower with western transepts forming a narthex of great size and height. This arrangement of a narthex is a common type of the churches in this district, the whole of the western front of the building being connected with lofty arches opening into the towers or aisles, as the case may be, and reminding one not a little of the similar arrangement at Peterborough.

S. Mary's appears to have been in building during all the former half of the 15th century, and was completed in 1470. It shows that poorness of detail, particularly in its window tracery which characterized the later brickwork of the district, whilst the rough way in which the eastern ambulatory is set out shows a carelessness and disregard for regularity which is also too common in the otherwise fine buildings of the period. The western front of the tower is faced with what is called Swedish stone in alternately thin and thick courses, an arrangement very rare in Pomerania, but the whole of the church, like the two I have already referred to, is raised on a high plinth of wrought and coursed granite boldly moulded at the set off.

The Rathhaus of Stralsund, begun in 1316, is more curious than beautiful. It is of the same character as the better known example at Lübeck, and the upper part, which alone of the whole building remains unaltered, is simply a huge screen wall to hide the roofs and buildings behind. It shows on the principal front six lofty gables separated by small turrets, and having over a series of pierced arcades, large uncusped circles in the gables open to the sky. These gables bear no relation whatever to the roof of the building behind, but are much more lofty and have to be supported by an intricate arrangement of iron rods and props.

At Stettin on the Oder, the large church of S. James shews a somewhat different treatment. It consists of three aisles with a polygonal termination, a large western tower and chapels between the buttresses. The aisles are of equal height and the space over the buttress chapels is thrown into the church and groined again at the higher level. The interior is very coarse, and the groining, which is worked without ribs, is of a most confusing and haphazard character. The roof is in one span over the whole. The side of the church shows a double range of large windows, the lower ones opening into the chapels and the upper ones into the aisles. The position of the buttresses is strongly marked by a slight projection boldly moulded at the angles and arcaded above, and in the lower part formed into niches on more highly enriched arcading. This feature, which is repeated with variations in other parts of the district, is particularly well worth notice, not only for its effectiveness and simplicity, but for its capability for considerable further enrichment.

A smaller church at Stettin, dedicated I believe to S. Nicholas, shows a plan less common in the neighbourhood. It consists of a nave with aisles on each side and a somewhat long close choir with an apsidal termination shewing seven sides of a decagon. The nave and aisles are of equal height, covered by a single roof, and with the space between the buttresses thrown into the inside of the church. The gables of the nave, which are thus of considerable size, are enriched with arcading, and broken up with a series of small open pinnacles stepping up gradually to the top. There are here, as in S. James's, two stages of windows, and in this case they are separated by a richly moulded band of vine leaves, in blocks about twelve inches square, carried along under a brick string.

S. Peter's church near the castle has been to a great extent reconstructed in more modern times, but the side walls of the nave shew a series of niches on the buttress projections, the corbels of which are formed by full-sized heads boldly carved in red bricks.

At Anclam are two churches, each possessing a tower fortunately with its original spire. Of these S. Mary's church is the largest. It is a three-aisled church covered with a roof in one span, and having a single western tower at the end of the south aisle, which appears at one time to have had a fellow at the end of the other aisle. The arrangement of the tower is very similar to those of S. Nicholas at Stralsund, but fortunately the completion in this case remains of the same date, apparently, as the lower part. Each face has a gable of a rather low pitch, covered with blank tracery of arches, circles, etc., and surmounted by an octagonal stunted spire. The other church dedicated to S. Nicholas has a single western tower more pleasingly varied perhaps than the last. It shews two square stages above the point at which it emerges from the roof separated from each other by broad bands of simple walling. The lower stage has on each face three arches containing three lancet-shaped lights and the upper stage consists of four arches, the outer ones narrow and blank and the inner ones of two lights each, an arrangement like the one so common in Normandy. Above these stages each face shews an arcaded gable surmounted by a lofty spire. The church itself is three-aisled, each aisle ending with a separate apsidal termination at the east end. In spite of this, however, the projection of the buttresses is used to corbel out the eaves line to as near a square as possible, so that by dint of a little awkward contrivance, the roof is hipped off squarely at the east end, and it is really some time before it strikes one that it is not a flat east-ended church. One only of the important city gates of Anclam remains. This is a lofty gabled tower, known as the Stein Thor, though no stone is used in its construction.

None of the places I have hitherto mentioned, however, contain work of such varied interest as does Stargard in Further Pomerania. Its distance from the sea and the fact of its being away from any important district of commerce have saved it from the changes which most towns have more or less experienced. Its walls and gates remain nearly perfect, and its churches and houses seem to have suffered less from change and destruction than from gradual decay. Its principal church, dedicated to S. Mary is of a first class character both for size and decoration. It consists of three aisles with the usual arrangement of buttress chapels and has two large unfinished western towers. The nave and choir are treated in a quite distinct manner, the chapels between the buttresses being also omitted in the latter. The church is exceedingly lofty and shews in the choir the unusual feature, in these brick churches, of a triforium under the clerestorey. The piers of the choir, which are octagonal in plan, have a large niche in each face under the cap as at Milan, but there is no sculpture left in any. The whole of the church is vaulted in brick, the centre aisle being particularly rich in the arrangement of its vaulting ribs. The northern of the two western towers is crowned by a lofty octagonal lantern in two stages covered with a copper dome with pinnacles at the angles of the tower. The exterior of the church is richly ornamented by moulded brick tracery. The buttresses of the choir are externally emphasized in the same manner I have already noticed at Stettin, but the arcading of the lower part is much more ornamental. The canopies and tracery are moulded almost entirely in black glazed clay, with the crockets and finials most boldly modelled. In spite of the number of niches and apparent preparation for statues, I did not find anywhere any trace of them, but in smaller features, such as angle crockets, corbels, etc., there were many specimens of animals and grotesque carving.

Another brick church, dedicated to S. John, and less important than S. Mary's, has on its west front a square massive tower begun in 1408, but still unfinished. It shews on each face three blank arches of two panels each, broken with circular windows about half-way up the tower.

Outside the walls is a curious and late church almost entirely erected of wood, and thus presenting a contrast to the general run of work in this country, the more remarkable as the profusion of timber with which the forests are stocked rarely induced the architect to use it in place of brick.

The city walls are formed of the granite boulders roughly faced and built random, but the towers and gates scattered round the town are of brick throughout. Through one of these the river Jena, on which Stargard is built, passes; and this gate, like the rest of them is of a most varied and picturesque description. There is scarcely any view of the town which does not include one or more of these, and they with the great towers of the churches, make up for form and colour one of the prettiest groups ever imagined by seekers after the "architecturesque."

The buildings in the Island of Rügen are of an interesting character, for although the churches are much smaller than those of the main land, some of them are among the oldest in the province. Among the most ancient works in the island is the great Herthaburg, a huge rampart of earth, of a circular form in some parts seventy feet high, on the banks of the Hertha See, in the beech forests of Stubbenkammer. The church of Bergen consists of an apsidal ended church with east and west transepts and western tower and spire dating from the end of the 12th century. At Sargard is a church with small western tower dating about 1240, and at Vilmnitz is one with a lofty spire of about the same date. These works are of a much simpler class than those we have already noticed, but the number of the buildings scattered over the island of about this date show that during the 13th century Rügen was in a well peopled and prosperous state.

At Pasewalk in the south of Pomerania are two large churches. The older one dedicated to S. Nicholas, dates from about the early part of the 13th century, and has a low western spire. The other and more important church dedicated to S. Mary is of considerable size and rich in its external decoration. It consists of three aisles of equal height ended eastwards by apsidal terminations arranged similarly to those at S. Mary Anclam, but in this case the eaves have not been corbelled out to form a square termination, but have been worked off to a bad curve by brick arches spanning the internal angles of the plan somewhat in the same way as at the east end of the Abbaye aux Hommes at Caen. It seems an earlier effort than that at Anclam to get over the difficulty of making careful finishings in tiles of the numberless hips and valleys produced by the intersection of the various roofs of an apsidal east end. At the west end of the church is a lofty tower with a rich brick spire, and at the north and south side of the apse are elegant little turrets crowned with crocketted roofs.

Two or three circular and square towers of the old walls similar to those of Stargard remain, but in a very much less perfect state.

Prenzlau, a town slightly to the south of the borders of Pomerania, and at one time capital of the Uckermark, contains work of the same character as some which I have already noticed. The walls were originally finished in the same manner as Stargard, etc., with round and square brick towers at intervals, and the intermediate walls of granite. These have, however, suffered more from alterations and destruction than most of the places of the district, as the town is still thriving and increasing in size. One of the gate towers is very similar to the Stein Thor at Anclam, and is curiously enriched with large shields, apparently of plaster, which may have had arms emblazoned on them. Each shield is *couché*, and reversed in position to the one next to it. The town is built on a hill which slants rapidly down from the east to a small river, along the side of which the old walls run. A tower which guarded at once the entrance to the town and the river passage still remains. It is a curious but happy composition of granite and brick, and the effect as seen on entering the town in combination with the church towers behind it, is most charming. The lower part of it is built of coursed granite, square on plan, from which rises the octagonal storey above in red brick. Well worked corbels of granite support a boldly projecting gallery, which runs round the centre of the tower and above rises a circular storey capped by the usual pyramidal roof. On the faces are panels of plaster which may have been covered with paintings or inscriptions, or possibly have contained brick tracery which has fallen out.

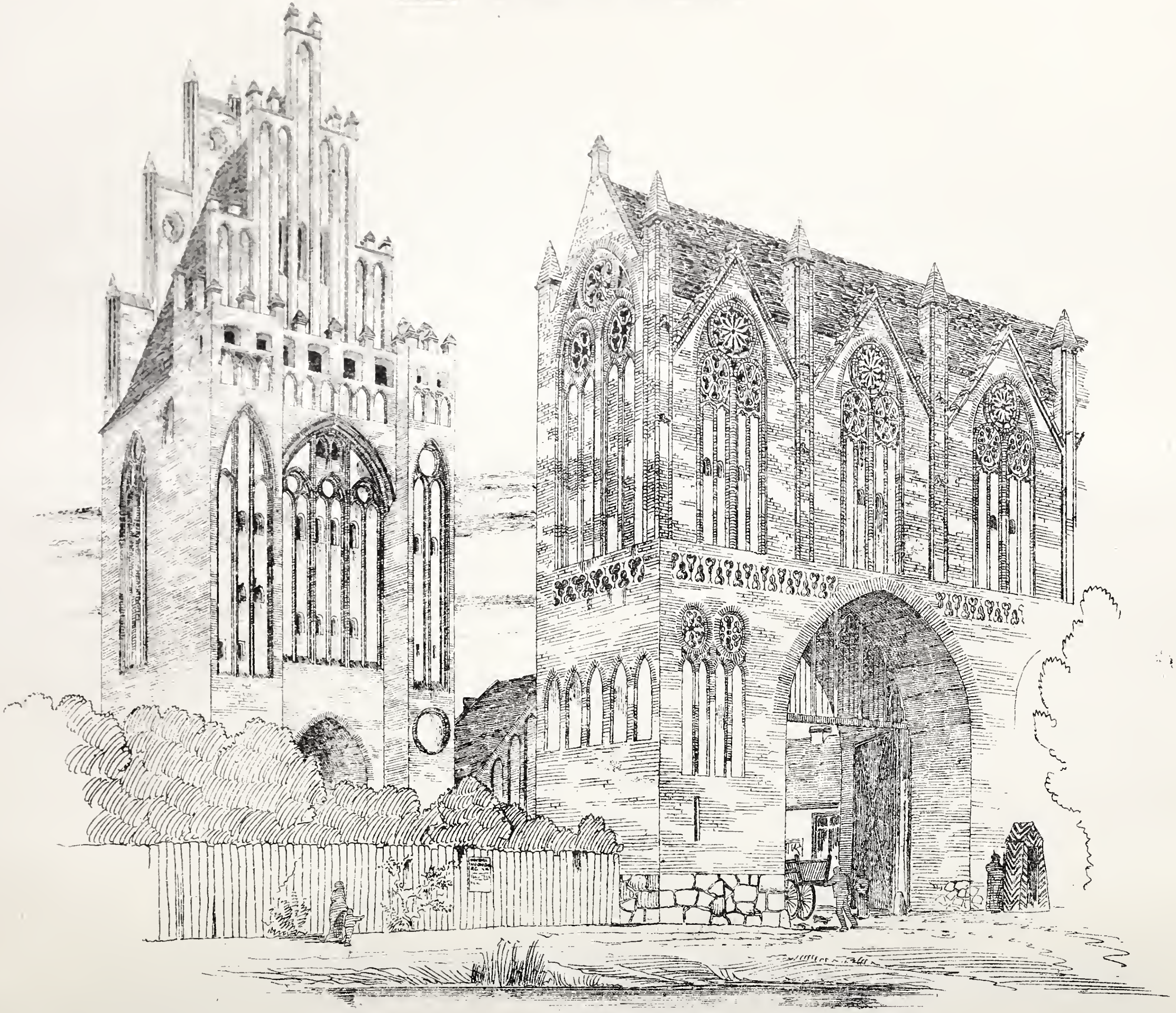
Near this tower is a small chapel, now belonging to a hospital, with a little turret rising over the gable of the west front. It is octagonal on plan, two stages high, and built entirely of glazed bricks in various colours, chiefly green.

The principal church of the town, dedicated to S. Mary, is said to have been begun about 1325 and finished in 1380. It is a large three aisled building eight bays long, with the three aisles vaulted over at the same level, and covered over with a single span roof. The aisles are ended eastwards with apses, but by means of buttresses and other projections these are brought to a level line at the upper part, so that a gable of large size is formed, and the east end at first sight appears to be quite square. This gable is one of the richest in Germany. Its proportions are very good, and the happy way in which it appears to grow easily out of the walling below, added to the graceful and flowing curves of its tracery, make it as beautiful as it is ornate. The great expanse of roof, which is the result of roofing over so large a space with a single span, is broken by a somewhat high open parapet of brick. The piers are well moulded and they, as well as all the details of the exterior, are constructed in brick. The church has lately been restored, and the whole of the interior painted the colour of rather yellow gray stocks, and the joints emphasized with colour; but as I believe the natural tint of the internal bricks is red, the effect originally must have been much more satisfactory than it is at present, notwithstanding the good proportions and careful detail of the interior. The western facade shows two lofty towers, which, with the gable between, are almost entirely constructed of granite. The plain unmoulded character of the openings, and the general simplicity of the facade, would, if the work were in a different locality, lead one to assign an earlier date to the work than that generally fixed, but this is doubtless due to the character of the material employed for work generally executed in a much more plastic material.

I have now only the town of Neubrandenburg left to describe, but this is by far the most interesting of all the places I have yet noticed. It is the second city in the Duchy of Mecklenburg Strelitz, and contains now a population of about six thousand people. The town was said to have been founded by John the First, Markgraf of Brandenburg in 1248, probably as an outlying fortress to protect his country against the Wends of Pomerania. But it appears shortly afterwards to have passed into the hands of the Dukes of Mecklenburg, by whom it was used as a permanent residence. None of the present buildings seem to be of so early a date as the middle of the 13th century, and it is probable that at first the town was simply a wooden stockade or outlying fortress raised purely for purposes of protection, and similar to the towns founded by the Teutonic knights along the north-eastern parts of Prussia. It would be a matter of great interest to fix exactly the date of the permanent foundation of the town, as the peculiarity of its arrangements suggests comparison with a class of works in another part of Europe with which this town appears to be contemporary. As far as can be judged from the appearance of the buildings, it is not unlikely that the permanent buildings were commenced about the date given for the taking possession of the place by the Dukes of Mecklenburg, namely the end of the 13th century, and that the town was then laid out in the plan we now find. The shape of the town is roughly square, with the angles rounded off, and crossed by straight streets about half a mile long at right angles to each other, with gates opening out to the principal country roads. The town is thus divided into squares of buildings, one being occupied by the Rathhans and Ducal palace, and the other with the church of S. Mary. When we remember that during the latter half of the 13th century the towns of Montpazier, Villeneuve-le-Roy, and others in South France, as well as Winchelsea in our own country, were being built on this same careful plan, it is impossible to avoid wondering if they could at all have suggested the arrangements we find in this place, so far removed as it is from them, and so unique in this part of Europe. The houses themselves are altogether of a more recent period than that I would assign for the placing of the town, but the unaltered position of the street is pretty well demonstrated by the position of the gates and public buildings. The town was besieged and burnt by Tilly in the Thirty years war, and suffered severely by fire two or three times in the 17th century; and the townspeople have displayed their wisdom at the restoration by re-building the houses in every case with an open space between them. The oldest building in the town is the church of S. John, which is now partly desecrated. I think it is quite possible that this is part of the original town, as it obtrudes slightly on one of the main intersecting streets; and it may have been erected with permanent materials soon after the founding of the place. The principal church is that dedicated to S. Mary, standing nearly in the centre. It is a three aisled church about 220 feet long, and 90 feet wide, vaulted at a level throughout, and covered with a roof of a single span. The west front is formed into a lofty narthex with the tower rising out of the centre, crowned by an elaborate open work spire. The vaulting is carried by boldly moulded and loftly brick piers, and the vaulting ribs are all worked in moulded brick. There is a high blank arcade round the internal walls pierced with a single circle, and above rise lofty four light windows filled with elaborate brick tracery. The exterior of the church, however, is most interesting. The east end is square and shows above the three windows lighting the three aisles a lofty brick gable ninety feet across, consisting of gabled arcades of pierced tracery and lofty open work pinnacles. This work is said to belong to the first half of the 14th century, some time before the date assigned to the rich gable of the church of Prenzlau, which is much more rich and varied in its design, and has less of the mechanical exactness exhibited by this specimen at Neubrandenburg; a sign I believe of the later and less artistic work. How far this may be due to the restoration which this church has recently undergone I cannot tell, as I have been unable to procure any photographs of the church in its original state. The spire, at least, I should imagine, has been re-built; and the general effect, although rich and varied, suffers from the free use of an ugly coloured gray stock with the red brick of the rest of the building, and from the harsh lines of the parapet which appear to cut off the light octagonal spire entirely from the massive tower below. The church is raised on the usual bold moulded plinth of squared granite, which I have already noticed in Stralsund, etc. One curious use of the granite in this church is shown in the south door where the central shaft is in one piece of carefully worked granite, whilst the caps and bases are still in the moulded brick of the rest of the building.

The great point of attraction at Neubrandenburg is, however, the fortification. It is surrounded by a double line of fosses, each about fifty feet broad, divided by lofty dykes, and having on the inner one the walls which form the chief defence of the town. The place is built close to the shores of the great lake known as the Tollensee, and no doubt means originally existed for turning the water into the ditches. The walls are of granite, and are strengthened at frequent intervals with small square

MEDIÆVAL : BRICKWORK : IN : NORTH : GERMANY



towers, all of which still remain. The gates which give access to the outer country, while of an ornamental character, were evidently constructed with careful regard to the means of defence. As they remain at present they consist of a barbican built on the outer dyke, and a lofty gate tower on a line with the inner walls. These were no doubt connected with drawbridges which have now, however, given place to permanent roads. The barbicans were two-storied buildings, the lower one occupied by guard-rooms and the entrance gate, and the upper parts showing to the outside a richly gabled and pinnacled front, with blank windows filled in with rich but simple tracery. The great tower is finished with a high gabled roof, and shows towards the dykes an arcaded front pierced with windows and surmounted by a gallery which looks as if it had been adapted at a later period for the use of guns. The inner side, towards the town, is divided into a number of tall narrow blank arches, stepping down with the crow step gables, across the centre of which is a series of very curious figures of rude workmanship. They are of some considerable size, and seem to be of terra cotta, apparently made in the same mould and built up in pieces into the wall. They all have their arms outstretched, and feet dangling under their long robes, like the figures from Noah's Ark in a state of suspension.

These gates, of which there are four altogether, have been, with one or two of the circular watch towers which occur in the walls, recently restored; but this work does not appear to have extended much further than replacing broken pinnacles and battlements, and filling in missing tracery to the windows.

In attempting to give any account of the style in which the buildings we have been noticing are erected, there are some facts which have to be borne in mind. To a certain extent the style was not indigenous to the country, but was imported complete when the necessity for buildings was suddenly felt. At a time when important works were going on in other parts of Germany, the Wends of Pomerania were scarcely converted to Christianity, and were sunk in barbarism. But the civilized states of Brandenburg and Mecklenburg leaning on their borders, and the influence and warning conveyed by the progress of the Teutonic knights caused a great change in the country; and although we are not able to trace it step by step, we find suddenly in the middle of the 13th century evidences of prosperity and taste in the numerous buildings which began to spring up in all the towns. Whether artists were invited from the surrounding states, or whether native workmen gained their knowledge by travelling, they seem all at once to have commenced the erection of edifices, perfect in style, and complete in all the appliances of ornament and construction. The buildings, prior to this time, were so poor and unimportant, that they themselves could not have afforded the experience required for the erection of such works as for example the Nicholai Kirche at Stralsund. Another noticeable point is that as a rule starting from the date I have named, the earlier buildings appear to be the most enriched, and after this was maintained for a century or so, they fell off from the florid character they first assumed to a baldness which even their enormous size and proportions can scarcely atone for.

With the material the builders had in use, two modes of decoration were open to them, of which they availed themselves, sometimes apart, and sometimes in combination, viz:—moulded or carved bricks. and enamelled bricks for coloured decorations. The latter method was one much adopted in the Old and New Mark and about Lübeck, but it was so rarely adopted in Pomerania as scarcely to modify in any degree the style of the buildings. The cast or moulded work was, however, the characteristic charm, and to a great extent the ultimate cause of the destruction of the style.

The workmen were not long in discovering the ease with which a great variety of design could be produced by different combinations of a few simple patterns, and we accordingly find the earliest and most general decorations employed to have been small cusped bars and circles, which singly or together were built on the face of the walls in the panels. In high class work, such as some we have noticed at S. Mary's, Stargard, the workmanship was of a much better and more artistic class, and the variations in the different portions show that each was separately and carefully modelled and built in an ingredient part of the structure. Generally however the work was of the more easily made sort, and in consequence the moulded shapes, although they often produce exceedingly satisfactory and ornamental finishing were of such an unsubstantial and structurally useless character that they soon decayed and fell out, leaving only ugly sockets and gaps to the detriment of the building they were intended to adorn. The facility with which it was found they could be added to the work after its completion seems frequently to have suggested their omission until some later period, which in too many cases never arrived; while in the later work it seemed to be rather the rule to omit the more ornamental work of the earlier time, and the unshapely panels and blank arches which former builders had prepared only for a means for holding decoration, were imitated for their own sake, and bare walls and untraceried window-heads are unfortunately too often the characteristic marks of the later phases of the style. The most common form in use was a bar forming one side of a trefoil or quarterfoil, three or four of which formed a complete pattern, and these were produced indefinitely in long panels, as round the towers and under the arcades, and sometimes over large wall spaces, gables, etc. Sometimes these bars were of great size and elaborate character, and must have been made with great care to fit together, as in the south door of S. Mary, Neubrandenburg, where three cusped bricks or pieces of terra cotta, each three feet six inches long, form a handsome rose window within a plain brick circle. The ordinary plain mouldings employed in these buildings have a distinctive character of their own. They are, with few exceptions, worked in the same sized bricks as the rest of the building, and necessarily show a smallness of detail as compared with stone, resulting from the size of the material employed. It is in its plain mouldings that this class of work shows to great advantage, for the nature of the manufacture requiring the repetition of the same design, a rich and pleasing effect is gained by the use of one or two good sections. These mouldings appear almost invariably to have been moulded bricks, but some at S. Nicholas, Stralsund, which church has a very fine series, appear to have been cut after they were in position. Not a little of the ornamental work in some of the earlier buildings appears to have been carved like stone after it was in position, as for example the heads in the buttress decoration of S. Peter, Stettin, and the corbels at S. Mary, Stargard. Another very effective but simple mode of decoration, found in thirteenth century works, was the breaking of the long rolls at the angles of the buttresses, etc., with a boldly projecting brick corbel, often emphasized by a hollow on either side, and carved into a grotesque head. This will be seen in the details of S. James, Stettin and S. Mary, Stargard.

The traceries of the windows were in 13th and 14th century work of a most elaborate description; they appear to have been built up entirely of moulded bricks without any support of iron bars, other than those used in the glazing, although at times the mullions are of an enormous height. The windows of the later phases of the style display however all the baldness and want of design which characterizes the rest of the work; for anything more ugly than the monstrous windows of S. Mary's, Stralsund, divided into six or eight lights by mullions passing straight up into the heads, could not easily be imagined.

Some of the best examples of decoration by enamelling the bricks are to be found in Stargard, a great part of the decorative terra cotta being black glazed clay, where, as in this case, if they are used with red or dark bricks, the effect no doubt was always satisfactory; but when a number of bright colours, washed clean and brilliant by every shower of rain, are built together in a mass, it required the lapse of centuries, and the decay inherent thereto, to mellow and harmonize the whole. The great west door of S. James', Stralsund, has the jamb mouldings built up in large blocks of glazed terra cotta, but in this case the colours were all deep browns and blacks, and could never have had the staring look of the little red and blue turret I described at Prenzlau.

The bricks of which all these buildings are formed are chiefly remarkable for their size. At Passewalk I measured some 11 by 5 by 3½ inches with a full ¾ inch mortar joint. At S. James's, Stettin, they were the same size, whilst at Lübeck some which were being removed from an old wall during the restoration of the cathedral I found measured as much as 11½ by 5¾ by 4 inches. The colour is a brownish red, and the mortar joints white, so that although we say that all the buildings are red brick, they never have the staring red colour we have too often to associate with a new red brick house in England.

Before concluding, there are one or two points which have been incidentally mentioned in the planning and arrangement of the churches to which I would particularly recur. One of the first things to strike one is the common arrangement of a large open porch or narthex across the west front of the churches. Whether there be one or two towers in the front the internal arrangement is generally the same, and where there is a single tower, as at S. Mary, Stralsund, transepts are thrown out beyond the tower to form this large hall. There are two types of towers common in the district, one the gabled square tower with the spire over, so common in Germany, of which we see perhaps the best example at Limburg-on-the-Lahn, and the octagonal lantern with angle pinnacles, examples of which indeed are scattered throughout Europe, but which seems here to have been a type carried to considerable perfection. Where, as is often the case, the aisles were built of equal height, the roof over the whole church was in a single span, and the architects gained a space in the eastern gable for lavishing all their favourite display of panels and cuspings. Thus these gables come to form a most prominent feature in the principal buildings, and we have already seen at Prenzlau the ingenious expedients resorted to to gain an important addition to an apsidal ended church.

In conclusion, I have to express a hope that you are not wearied with details of buildings which may be considered to have many faults of style—faults due however not so much to want of taste perhaps as better means to express it; and I trust you will see that there are many points of excellence to be noted in these buildings, erected as they are of materials so similar to those at our own command, and that English architects may learn something from the Mediæval Brickwork of Pomerania.

The CHAIRMAN.—I think we have many gentlemen present who may have something to say upon the subject which Mr. Perry has brought before us. Mr. Street has had great experience in brickwork, and perhaps he will give us the benefit of his remarks.

Mr. STREET, Fellow.—I would first suggest, Sir, that we should pay Mr. Hooke the compliment of asking him to give us an explanation of the charming drawings which tend to illustrate this paper. [Mr. Hooke having briefly complied with the request made to him] Mr. Street said: I am sure, Sir, we must be very grateful to Mr. Perry for his paper, and to Mr. Hooke for assisting to illustrate it by these interesting sketches. You have called upon me, Sir, because I have been referred to as knowing something about the brickwork of North Germany. But it is only as far as regards other parts than Pomerania that I know anything about it, though, as far as I can judge, the same style is found to extend over the whole of the north of Germany generally. If you draw a line through Berlin on the map, from east to west, you will find that the whole of the towns north of that line up to the Baltic and North Sea, and in Denmark, are filled with brick buildings of the middle ages, and as far as I gather from what I have seen myself in books, and from Mr. Perry's paper, there is no difference in principle in any of these works, all of which have been developed expressly to suit the use of bricks; and therefore, if I say a word on this subject generally, it must be not with regard to buildings in Pomerania itself, but as to those of the same class elsewhere. As Mr. Perry states, I published some years ago a description of the churches and other buildings of Lübeck. It is not a little remarkable that the great open brick screens in front of the Town Hall at Lübeck are almost absolutely reproduced in a similar position in one of Mr. Perry's drawings from Stralsund. It will be found that one of the great characteristics of these North German churches is the erection wherever possible of parapets, screens to gables, and cornices of moulded brickwork. This is a special feature of these German buildings; but it is curious to observe that wherever brickwork was made use of in the middle ages, the same fashion prevailed of making a display of it for the mere pleasure of doing so. The explanation of this is, I think, that the old brickmakers having made a good mould, wanted to use it as often as they could, and being proud of their work and material, showed it every attention; very unlike our modern brickmakers, who seem to be so ashamed of the materials they commonly make, that they never care to show it, and the architect, only too often sympathising with them, daubs their bricks over with compo, so as quite to conceal them. In Germany, people preferred to show their bricks because they were well and carefully made, and the goodness of the material is shown by the fact that it has lasted in such a way that these buildings are more perfect, and less altered than stone buildings in almost any part of Europe. I confess the first sentiment that occurs to me on hearing the descriptions of the buildings brought before us this evening, is that the younger members of our profession, if they care for their art, will all, without delay, ask for leave of absence from their work, and go to this part of the continent to inspect and sketch these charming works for themselves. But I have some doubts whether they will do so, when I see, as I have lately, that they appear to be so far from fond of going to the North of Germany, or anywhere else on the continent to sketch, that absolutely not one among them has competed for this year's travelling studentship at the Royal Academy. I should like to ask Mr. Perry in what condition he found the internal furniture of these Pomeranian churches. As far as I have seen in the churches of Brandenburg, Mecklenburg and Lübeck, the furniture was one of the most interesting features. Some of them had an enormous quantity of old furniture, old vestments, old presses, in the vestries old plate and old pictures—everything in the old churches being left without alteration in the most perfect state. I hope we shall hear that in this respect also there is much to be seen in Pomerania. Among the sketches on the walls that which strikes me most is the number and magnificence of the old town gateways and walls. As will be seen from these sketches of Mr. Hooke's, they are most peculiar, and when seen as they are rising one behind the other, in front of the old churches, they are beyond measure beautiful. Then again, the gables are to the same extent very charming, and one cannot but admire their magnificent effect. The great gable at Prenslau especially, is a very fine one, and the tracery patterns with which it is filled, are so simple, that one can pardon the repetition of them by their architect for the mere pleasure of it, when the result is that you get such a broad and beautiful composition. Let me, in passing, observe that when Mr. Perry speaks of the foreign influences on Pomerania, he must not forget that the country was converted to Christianity by an Englishman, who, however, was too early in the field to have left any influence on its architecture. I would conclude by thanking Mr. Perry, once more, for the pains which he has taken to prepare this paper. I am sure we ought always to welcome heartily the younger members of our body who illustrate with the same zeal, things which we may not have seen ourselves, but in which we all know there is so much to admire.

Mr. C. Fowler, Fellow: I rise with peculiar pleasure to second Mr. Street's proposition of a vote of thanks to Mr. Perry for this interesting paper. It is one which is particularly interesting to me, because although I am not acquainted with the exact places to which Mr. Perry has taken us, I have visited others in the North of Germany where similar buildings are found. Some of these places Mr. Perry has not visited, but they are illustrated by Mr. Hooke's drawings,—some of the subjects of which I happen to know. Stendal may be mentioned as a very remarkable old town. When I visited it some twenty-five years ago, it appeared much the same as one might imagine it to have been in the 14th century, when these quaint and peculiar buildings were erected. The whole of the mediæval walls were standing intact, and the towers at intervals the same, with the exception of some of the gables which were knocked over, but retaining all the principal features. None, however, were so fine as those which Mr. Perry has shown us to-night, and that has made his paper interesting to me. His theory is that this style was imported into Pomerania from an adjacent country. If so, it is very remarkable that the buildings should be about co-eval: for as far as I gather and remember, the erection of most of them falls in the 14th century. Now if this style was imported whole and ready-made from an adjoining province, it must have taken place very rapidly. It is curious that here, as well as to a great extent in Brandenburg, you find but few of the very early buildings. Mr. Perry says in Pomerania there are scarcely any at all, and those are constructed of brick. Possibly the absence of the earlier buildings is due to the fact that in the 14th century that country was in a high state of prosperity, and the earlier buildings were pulled down to make room for the magnificent churches and other edifices which were then erected; but the few early buildings which remain are most interesting. Mr. Perry has scarcely directed our attention at all to the domestic buildings in this style. I do not know myself how far there may be many or good examples in the places he has visited, but in Brandenburg and the Hanseatic Towns, many fine specimens remain. They do not present great variety. All are gabled and the principal variety is in the number and arrangement of the panels which fill in the gables. The windows are arranged without much reference to the gables, which are the chief features of the houses. At Lubeck there are many of these buildings, which give an extremely peculiar character to the streets. There is one point which struck me in the construction of the churches, and that is the way in which the vaulting is executed. Without exception they are vaulted in brick. The spans are considerable, and the vaulting is of a simple character. They built the ribs first, and filled in the spandrels without centering. The spandrels are very much domed towards the crown, and on the upper surface of the vault show a series of knobs which have an odd effect. They scarcely ever filled in the haunches of the vault, which was about six inches thick, so that the form is distinctly seen on both sides. There are no ridge or wall ribs. To the quality and character of the bricks, Mr. Perry has called attention, and it struck me as adding greatly to the effect of these buildings that they are built with large fine-coloured, as well as fine-burnt bricks, and with wide joints of fully three-quarters of an inch. Looking to the very large size of these bricks we may imagine some difficulty in the handling of them. At Hamburgh, in the re-construction of a large church which was burnt at the time of the great fire there, the architect used the same description of bricks as the old ones, but he had great difficulty in getting them manufactured, and still greater difficulty in getting them worked by the bricklayers. The work was carried out strictly in the old manner. The bricks were obtained from Rathenau, from brickfields known to have been in use since the date of the principal buildings there, or from the 14th century, and are very satisfactory indeed. I beg to give my thanks personally to Mr. Perry, and to second the vote of thanks to him for his interesting paper.

Mr. R. Phené Spiers, Associate:—I am only acquainted with one of the towns cited by Mr. Perry, viz., Stralsund, but I have visited Luneberg, Rostock, Lübeck, and Dantzig, and the style of the buildings in each seems to be the same. I confess from a careful examination of the buildings, I arrived at the same conclusion as Mr. Perry, that the style was imported into the country from places where stone was the chief material. I am unable to recollect the date exactly of a very important building in the north of Germany, the Chateau of Marienberg, but I imagine some portion of it is of the 13th century. A large portion of it was built by the Teutonic knights supposed to have come from Venice, who introduced stone features from that place, which seem to me to have served as a model for the commencement of some of these brick buildings. Thus we find portions of the great hall at Marienberg are of stone, and there is a great similarity to it in portions of the brickwork in the remainder of the building. The style, became a natural one, because they found they were not able to get the same simple effect, and were obliged to adopt a certain number of models in ornamentation and repeat them, rather than have the variety which stonework gives. One point to which Mr. Perry alluded is the peculiar custom they had of carving bricks. It is seldom we can think of carving brick, as we imagine that when the surface is once destroyed, the brick will not stand the weather, but from what is shown here it is certain the brick is carved; and Mr. Perry mentions that in Pomerania he found crockets and other parts carved in brick. Some may have thought them moulded, but that is impossible looking at the depth of the cutting. At Marienberg, in the Golden Porch, the three orders of the doorway are elaborately carved, forming some of the finest pieces of brickwork it is possible to imagine, and the work looked as sharp and clean as when it was first carved. Another point is the immense length of the brick mullions without support. At Dantzig and Lübeck there are some simple brick mullions not more than six inches wide, which rise to a height of 70 feet without support, beyond that of the iron bars to hold the glass, and it is astonishing they should have retained their perfect verticality for so long. The tracery of these windows, in some cases extremely elaborate, is produced with four or five different forms only, and it seems extraordinary that such elaborate designs should be made with so few forms of bricks. The glazed brick, I think, is not a satisfactory invention; and the effect of glazed bricks alternating with unglazed is not good. The glazed brick retains its original surface whilst the unglazed material is eaten away, and the result in that case is anything but pleasing. The same treatment has been applied to domestic work in these countries, as far as I remember, except that there are but few houses which have lasted so long as the churches; but in Luneberg the houses are built in imitation of the churches, with regard to the large gables, and have the same decorative treatment of small octagonal buttresses, and the windows between. As a rule the ground plan is built in plain brickwork without decoration, and above that a number of piers rise through the other floors. I beg very heartily to support the vote of thanks to Mr. Perry, who has brought before us a subject of great interest of which but little is known in this country.

Mr. FOWLER: There is one point which I did not allude to, and that is with reference to carved bricks spoken of by Mr. Perry. My own opinion is that they are carved before being burnt. I looked carefully at these bricks, and I came to the conclusion that there was no instance in which the bricks were carved after they were burnt. The plan pursued I imagine to have been this:—very large masses of clay were dried to the consistency of firm cheese, and were then cut with fine wire, in which operation no doubt the workmen attained considerable skill. The carved work seems to have been somewhat roughly executed, but it produced a good effect at a distance from the eye; and in no case did I discover any work that seemed to have been carved after the bricks had been burnt.

Mr. H. W. BREWER, Visitor, said: Not being a practical architect, I am afraid I cannot offer any observations which will be of practical value; but I must say, this paper by Mr. Perry has been one of very great interest to me, because it has pointed out one of the difficulties under which architects laboured in the Middle Ages, and I am glad to find that architects in the Middle Ages had some difficulties to contend with. I do not think they had many, but this difficulty of material was a great one, because they had not only to discover the material but to find out how to use it. Under most other architectural difficulties they did not labour. They had not the difficulties which we have to contend with. Architects in the Middle Ages were not plagued by half-a-dozen clients—one wanting a church built in the style of the eighth, another of the ninth, whilst a third preferred one of the fifth or sixth century; but an architect of the thirteenth century built in the style of the period in which he lived, and was thus freed from one of the principal difficulties of the architect of the present day. They had not, I think, the same amount of stupidity in their builders which you gentlemen have to contend with. I often see a design made for a building which is a credit to the age; but it is spoilt by the whims of clients or the excessive stupidity of the builders. Mediæval architects had not that difficulty to contend with. It seems to me however, that the use of brick was really a difficulty to Gothic architects in the early ages, which I think is proved by the fact that when we see a country where Gothic buildings are entirely of brick, we find many features imitated from stone. Mr. Perry has told us that in one of these churches he has seen a large rose window made of three bricks, with a great deal of cusping. I would suggest that that cannot be a true treatment of such a material, and must be imitated from stone. There is also, I think, another thing which proves that mediæval builders did not like brick if they could get anything else. We find that in the low countries, in Holland and Belgium, and in the south of Germany, where the bricks were good, the cathedrals and other principal edifices are built of stone brought from great distances, although the houses are of brick. It is, however, interesting to see, when mediæval architects were confined to brick alone, what use they made of it, and hence the style developed into a different style to what it would have become if they had had the use of stone, as may be seen by comparing the buildings represented in the drawings exhibited to-night with the buildings in France and portions of the Rhine country where stone was to be procured. I venture to think the style developed by the use of brick was not so fine in effect, but was inferior to that which was developed by the use of stone: and this, to a certain extent, proves that Gothic architecture is a style more applicable to stone than brick. I regard it, in short, as a stone style rather than a brick style; and it seems to me that Gothic architects never appeared thoroughly to have understood the use of brick till Gothic architecture was about to disappear. I think the finest brickwork of the Mediæval Ages is to be found in the old Tudor houses of England. A notable example of this is to be seen in East Barham Hall, in Norfolk, the brickwork of which is, to my mind, superior to anything we find in earlier days. I suggest these as the views of an amateur. I think, however, the architectural student will do well to take Mr. Street's advice to visit Pomerania and study well the brick buildings of that province; and I am sure they will find in them a great deal that is worth their attention. I must just add, with regard to cut brickwork, that, at Landshut, in Bavaria, in the cemetery attached to the Church of the Holy Blood, there is a wall about 10 feet high, and in that wall there are a great number of monumental inscriptions evidently cut into the brickwork after the wall was built. These inscriptions are composed of large bold letters. This is a remarkable piece of cut work, and the only one I remember having seen.

Mr. Street.—With reference to the development of tracery, I differ from the statement made by two of my friends that this brick tracery is a mere imitation of stone, and I will give you my reason for thinking the contrary. We might, indeed, with more force, say that stone tracery was a copy of something made by the brickmakers, because you see that when once a moulded brick has been made, the effect of repeating the moulding is very often to produce tracery, and the result is the brickmaker having these moulds made, and being able to repeat the pattern at trifling cost, set to work and made tracery. Consequently, gables all over these buildings were filled with tracery for the mere sake of repetition, because they had a material which lent itself to such work. If you mark the development in all brick-making countries, you see the same thing, because it is a natural development. And the mediæval architects developed the resources of the material because they were much more competent men than Mr. Brewer, in what I hope is only a transient state of mind, gives them credit for being.

They were men constantly contending with difficulties and mastering them, and I believe their difficulties were quite as great as our own. At Cremona Cathedral and in the Grand Castle at Pavia there is no stone tracery to copy, but you find there very remarkable examples of brick tracery; and you find the same at Tarazona in the North of Spain, where the cloisters are filled with neat elaborate brick tracery, made up of constant repetitions of small pieces of brick, and certainly not copied from anything done in stone, but resulting simply from the natural and proper use of brick. We find the same in almost all brick districts. In reference to what Mr. Brewer has said as to East Barham Hall being more Gothic than any of these buildings, if that is so I confess I do not know what Gothic is. All these buildings in the North of Germany seem to me intensely Gothic. I think also that their style grew and was developed naturally, just as the art grew in all other parts of Europe. In Adler's, and still more in Herr Essenwein's book on the brickwork of the North of Germany, you will find a good many examples of Romanesque works in brick, and you have just as much illustration of the development of the later buildings during every period as you have in the case of stone buildings in the rest of Germany.

Mr. THOS. MORRIS, Associate, said.—I beg leave to offer a word or two in the interest of history and practice. We have just heard an admirable paper, and the remarks upon it have been very interesting; but I, who may profess to be still a student, wish to elicit information, because history is the surest help, and authentic dates are of the utmost value in architectural investigations. I think it desirable that a subject should be so far defined, that when speaking of brickwork it may be certain we we are not speaking of *terra cotta*, as there is an essential difference between them, but the distinction has not been very strictly observed. We know that Italy excelled in *terra cotta*, and that Lübeck was the grand seat of trade between Venice and the north of Europe. While moulded parts, therefore, could be carried by the score or the thousand from one part of the Continent to another, is it not possible that some of these decorative portions may have been carried from Italy by the Venetian traders to Lübeck, and thence distributed into the neighbouring countries? Were the history of this subject accurately traced, we should probably see the direction in which certain forms and peculiarities travelled. My other point relates to the material and mode of working. Mr. Perry mentions that at Neu-Brandenburg a large red kind of brick was anciently in use—a sort of tile—and brick walling appears to have been anciently called tilework in England and France. These red bricks seem to have been antecedent to what Mr. Perry properly calls the coarse or rough stocks. They have, he tells us, these coarse rough bricks in the Neu-Brandenburg houses, as we have them in England, and I am curious about the period of their introduction. In the time of Henry VII. and Henry VIII., this kind of tile or red kiln-burnt brickwork prevailed here, and it continued down to the time of Charles II. The stock brick then came in, and the time at which its use in Pomerania began seems worth inquiry. The kind of bond adopted may be regarded in the same light; for, while all brickwork should show *quarter bond*, our old red material was laid in the way known as English, and the modern system is termed Flemish bond. It may be allowable, therefore, to ask whether German work has the same distinctions, and, if so, at what date they arose. Comparisons are often desirable, and as we are upon the question of brickwork these details may not be out of place. As Mr. Street is still present, I would ask him to reconcile one apparent difference between himself and Mr. Barrow, the author of "Excursions in the North of Europe." The latter gentleman states that the houses in Lübeck are mostly built of *stone*, whereas Mr. Street intimated, in a lecture in another place, that scarcely anything but *brick* was ever seen there. I would therefore ask whether the houses are generally of stone and the churches of brick or church and domestic work of brick alike.

Mr. STREET expressed his opinion that the author referred to had mistaken painted brickwork for stone.

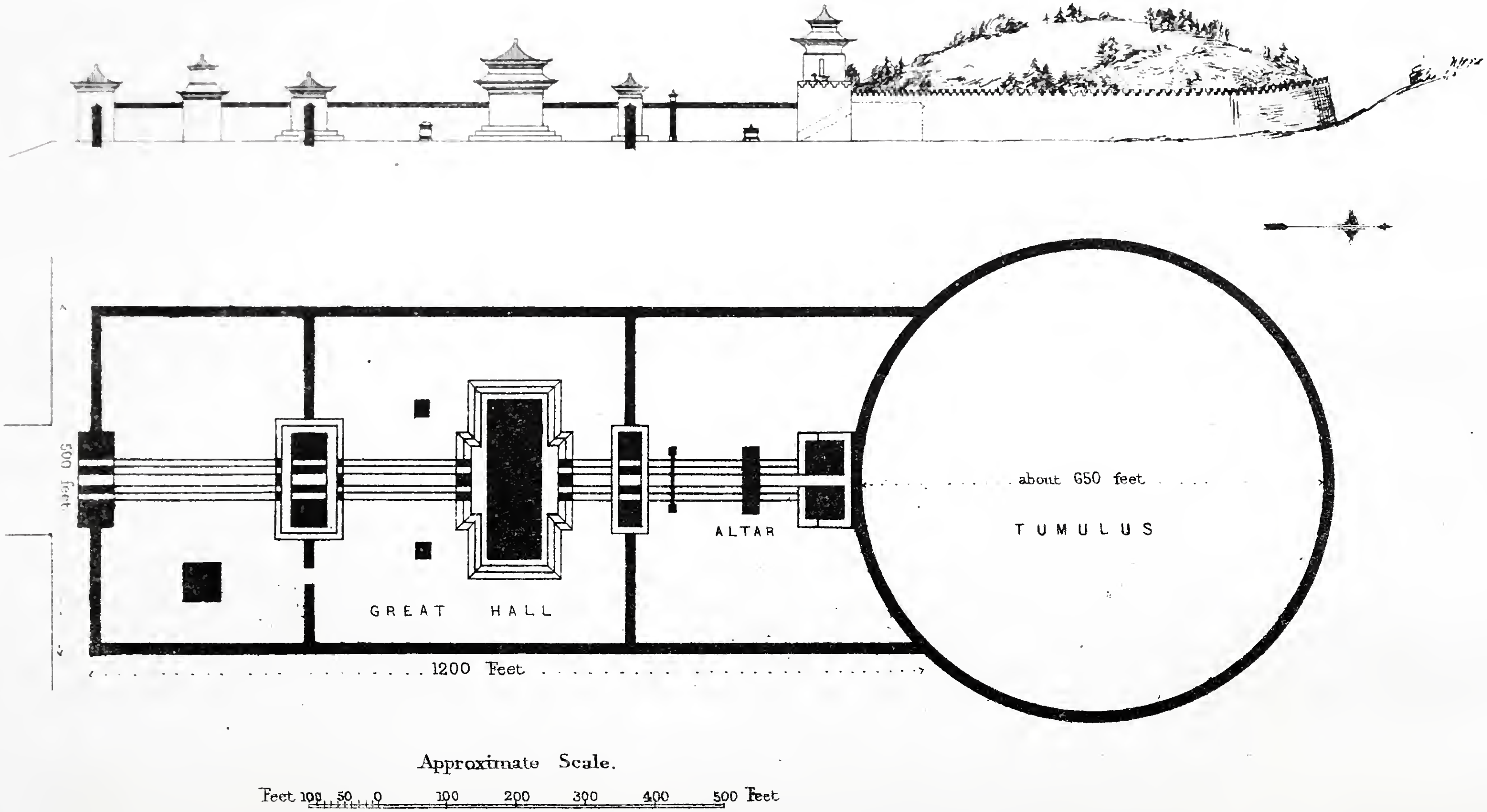
Mr. **Tavenor Perry** having acknowledged the vote of thanks, said: With regard to the furniture and decoration of the churches generally, I can say very little, as in almost all cases everything of value was cleared out of the country at the time of the Thirty Years' war, and the interiors of the buildings are all coloured over with whitewash. In S. Nicholas, Stralsund, however, there remains a very fine brass of the date 1357, and in several of the churches altar pieces of no great merit are left in position. But any one who knows the churches of Lubeck, and the magnificent series of ornaments remaining in them, will be very much disappointed with Pomerania.

The domestic work is generally of the class Mr. Spiers has been describing, but I noticed a very general use of plaster in some of the façades which had the appearance of being cotemporary with the rest of the building. It most frequently occurs in the blank tracery formed in the window heads, and was employed to fill up the rough intervening spaces of brickwork left between the cusped bars giving the shape of the recesses. Such houses as I was able to go over, I found generally constructed on the plan of a large entrance hall and central staircase giving access to various floors evidently designed to be occupied by different families as in the present day.

With respect to the brick carving, I must say I entirely agree with Mr. Spiers in his opinion that the work was executed *in situ*, and I think the heads shown in my drawings of buttress decorations at Stettin and Stargard, as well as the mouldings from S. Nicholas Stralsund, figured by Kugler, will sufficiently shew this. The general walling of these buildings to which I have referred was almost invariably executed in Flemish bond.

The discussion having thus been brought to a close, the vote of thanks was passed to Mr. Perry by acclamation, and the meeting adjourned.

SKETCH ELEVATION AND PLAN OF THE TOMB OF YUNG-LO, MING DYNASTY, NEAR PEKING.



C F Kell Photo-Litho 7 Cooks Court

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 1st of December, 1873, G. VULLIAMY, ESQ., Vice-President, in the Chair, the following Paper was read:—

THE ARCHITECTURE OF CHINA,

By WILLIAM SIMPSON, F.R.G.S.

IN that strange college in the island of Laputa, which Gulliver visited in his travels, he relates, among the seemingly impossible problems which its inmates were spending their lives trying to solve, that one was an effort to build a house by beginning at the roof. This, curiously, enough, is the Chinese mode of construction. The framework of the roof is first made on the ground on the exact spot where the house is to be. It is then raised up and the pillars are placed below to support it; and the walls are afterwards formed. Putting up a roof in this manner on wooden pillars reminds one of pitching a tent: and it is said that the peculiar curves of a Chinese roof are an imitation of a tent form, and that this is the real origin of Chinese architecture. Such may have been the case, but now the architecture of that country is essentially wooden, and these wooden forms may be found, as in other countries, repeated in stone and marble. Many important buildings are yet wholly of wood, such as the structure on the north altar of the "Temple of Heaven;" and the great hall of the Ming Tombs, which I believe to be one of the finest buildings in China. Stone is largely used for bridges, gateways, and for public works; while ornamental structures in gardens, for balustrades surrounding tombs and important buildings are generally of marble. Brick may be said to be the principal building material of China. When a roof has been made and put in its place, the space between the pillars is usually filled up with a brick wall. The walls of cities are built of this material, the brick being about eighteen inches long. For some temples and fine building work a very small grey brick is used; these are ground perfectly square and all of one size; so exactly is this done, that when built one could not insert the point of a knife between them, and the work produced will rival the finest specimens of work in any other part of the world. Tile is almost universally used for roofs. In palaces and temples they are often coloured and glazed. All palaces, temples, tombs and buildings erected for the use of the Emperor, or by his order, have yellow tiles, that being the Imperial colour; and it is a capital offence for any one else to adopt it. There are a number of very handsome pailows about Peking, in which glazed tiles or bricks are used, producing a very fine effect, yellow and green being the favourite colours. Byron's line, where he speaks of "small-eyed China's crockery-ware metropolis," does not, I think, convey an accurate idea of the appearance of Peking. Here and there a pailow may be found with these Majolica incrustations; one or two temples have coloured tiles; all the buildings of the palace have rich yellow-coloured roofs; but in such a vast place as Peking these instances are so few and far between that they do not become a prominent feature of the city. Peking is only an extended village of dirty streets and crumbling walls, where everything seems going to ruin, or it would be more correct to say, is in a condition of ruin already. In this wilderness of decay anything that could be called "crockery ware" in the architecture is an exception. Were such buildings common in Peking as the temple on the Wan-sheu-Shan, near the Summer Palace, Byron's line would have been applicable. With the exception of a marble base, it is wholly constructed of beautifully-coloured Majolica, rich and bright in effect, all covered with ornament and Buddhist figures. I should suppose that it is one of the finest specimens of this kind of work in existence, and it is highly satisfactory to know that when the destruction of the Summer Palace was ordered, the great beauty of the building saved it from the fate of everything around. Lord Elgin made a request that this work of art should not be touched. Close beside it is a very fine temple, formed entirely of bronze; as it would not burn, and could not be knocked to pieces, it has also escaped. It is very small, but it was curious to see in it almost every form of Chinese architecture repeated so perfectly in metal.

I exhibit a rough sketch of one of the buildings of the British Legation in Peking. Along with it are more minute drawings of the details, and a slight description will explain not only them, but at the same time nearly all the architecture of China; for its forms may be resolved into a very few points. The place occupied by our Legation belongs to the Duke Leeang, one of the offshoots of the Imperial family, from whom it is rented by our Government. It was called the Foo or Palace of the Duke Leeang, so it is a fair specimen of Chinese architecture.

All buildings of this kind are placed upon a raised stone platform, with steps for ascent. Some of the stones forming the floor are cut with circular discs as bases for the wooden pillars. The pillars are not inserted, but rest like the poles of a tent. I exhibit a small sketch of one of the large teak pillars of the Ming tombs with its stone base. At Nanking I noticed one of these base stones with a socket of about an inch in depth; but that, so far as my observation went, was an exception to the rule. In more common houses, where no platform has been made, circular stones are placed below the columns, so as to preserve the wood from the damp of the ground.

I may here remark that all houses are made to face the south. I think there is no exception to this in palaces and better class houses; although in the dwellings of the poorer classes it is not always attended to. The usual reason assigned for this is the peculiar deification of elements known as the *Fung-Shuie.* Those words simply mean wind and water, and they have much to do with everything in China. They control the architect as the sexton, for it takes a long propitiation and expenditure of means, as well to discover the proper site for a grave; and it will no doubt interest gentlemen who are connected, or at least interested, in public works, to know that this *Fung-Shuie* may be called the un-responsible head of that department in China. No one in that country would dream of constructing a bridge, a canal, an embankment, or quay, without first propitiating this great power with sacrifice and incense, so that its supreme will might be known. The public works of China made in former times are really splendid monuments of the industry and power of the country; but that is of a past date. They are all now in ruins, and works of a more modern European kind are wanted. Railways, telegraphs, and every improvement of the present day are ready to enter China; but then the Mandarin class are most bigotedly opposed to them. Supposing a railway or a telegraph was to be made in spite of the Mandarins, its probable fate might be thus. If any accident were to take place,—it might be some hundred miles away from the railway or telegraph,—the Mandarins would only have to say that the iron rails, or the telegraph poles, had interfered with the *Fung-Shuie*, and that while they existed similar events would occur. The result would be certain: the belief in this strange deification of wind and water is so deeply rooted, that the population would rise in mass, and the disturbing influence would be swept out of existence. I do not see that there is much chance for modern improvements being introduced into the celestial kingdom while the *Fung-Shuie* has the chief control in such matters. Of course, I have no doubt but steam, which may be looked upon as a newer Avatar of Wind and Water, will be the strongest in the end, and it is only a question of time when it will conquer.

To return to my subject. The relations of this *Fung-Shuie* with architecture are numerous. In the construction of a house it may have been a sanitary object which first gave rise to the connection. In a cold climate a southern aspect is looked for by those who wish for a comfortable, which in a sense means a healthy house. If the architecture of China came from the north,—and in that part of the country there is a cold winter, with biting winds blowing from the frozen regions of Mongolia,—a solid wall, or any other protection on that side, would be dictated by common sense. This simple object, no doubt, got worked into the religious ideas of the people, and is now only part of a ridiculous superstition.

A palace like the Duke Leeang's comprises a series of buildings, each behind the other towards the north. The sketch which I give represents the most southerly; and from it an idea may be formed of the others. As you pass through, they appear richer in material and ornament; but there is no essential difference of constructive character. The more private rooms of a palace are those towards the north, and in the flowery land very flowery names are given to everything, and the halls of a palace are no exception to the rule. You pass through the halls of " Heavenly Bliss " and " Steadfast Purity " to that of " Serene Felicity," which is in the extreme recesses of the place. There is only one floor in Chinese houses, and their distinctive feature is, that extent of accommodation is derived from the repetition of these halls, and not from stories above or extensions on the side. Houses in India, such as I have seen in Delhi or Benares, are quadrangles with rooms all round looking into a garden in the middle. A Pompeian house is only a variety of this. The Chinese plan is most marked in its difference. The sketch represents the first of these halls on the south, and only a comparatively small space at each end is walled in, indicating that it has only got accommodation for some outer attendants. Passing this, each hall has more enclosed space, and the most northern are walled entirely round. The ground between each is more or less in the form of a garden, with shrubs, flowers and plants. Two lion-like griffins, of stone or marble, or in palaces of bronze, watch the southern approach. There is still an outer wall, and you may be passing to a very fine palace in Peking, and see nothing but dirt and decay on the outside.

One very distinctive feature of this Architecture is what I may call the "frieze," but I confess that the term is doubtful when applied to this part of Chinese construction. It reminds one of the bracket capital of Hindoo architecture, and no doubt it had a similar origin. It is now a complicated triple succession of small brackets, which project forward, giving increased breadth on the top for the support of the roof. It would be almost impossible to describe this in words, but the sketches of detail, and a section exhibited, will make it tolerably well understood. Although evidently constructive in its origin and purpose, it is the most ornamental portion, and its complexity makes it perhaps the most striking feature of Chinese architecture. All buildings with anything like architectural pretensions will be found to have this peculiar frieze; and if you note it in my detailed sketches, you will then recognise it in all the sketches and photographs which I exhibit. Its origin is evidently wooden, but I have seen it repeated in stone, marble, majolica, brick, bronze and iron. Many of these forms are exhibited in the sketches. There are some varieties in the tiles of China; but those of Peking, particularly when they were of the Imperial yellow tint, suggested that bamboos had first been used for roofs, and had given origin to the round form of the upper tiles. In these cases the terminals are round, with an ornament within. I exhibit one from Peking from one of the Imperial palaces there; it will give an idea of the colour of the roofs. It has the five-clawed dragon as an ornament, another of the Imperial emblems which it is treason to copy. At each end of the ridge beam is a dragon, represented as being pinned down with a sword. It is called *Show-tow*, and is done to secure that fabulous animal as the protecting head of the house. In some of the grander temples and palaces, this top ornament is a very large and beautiful piece of majolica work. On the ridges leading to each corner of the roof are a number of smaller animals, which are also supposed to be guardians of the house.

While in Peking I managed to visit the Great Wall of China, and we planned our route so as to see the Ming tombs. I believe that they have never been properly described before, and I am sorry that time only permitted of a visit to one of them; but as that was the oldest and most important, a description of it must do duty for the others. We have all heard of the ancestral worship of the Chinese, but it would be difficult to realize it without a visit to the country. It leads to such a profound veneration for graves, that a Chinaman never disturbs one: he will plough round it from generation to generation, but he would never be guilty of the sacrilege of destroying it. The result is that the whole of China is one vast cemetery. The usual form of the grave is a mound, and there are places where, as far as the eye can reach, nothing but mounds can be seen, almost justifying the truth of Shelley's lines:—

> "There's not one atom of yon earth
> But once was living man."

The Chinese have no doubt buried in this way from the most remote antiquity, and a minute account of it would be of great value as bearing on the barrows and ancient grave mounds which are being explored in this country. I have to deal with them architecturally, and yet I feel that the little I have got to say is not without its importance as bearing on many points of archæological interest.

The chief desire of a Chinaman is, that a descendant shall always "stand at his grave," meaning by that phrase, the performance of religious rites. The present Emperor performs these ceremonies to all the deceased monarchs of his own dynasty. As the Ming dynasty ended in 1628, their tombs have had no one since that period to discharge the necessary services. The locality is about forty miles north of Peking, and a fine road with splendid bridges,—now all gone to ruins,—communicated with the capital, and by which the Emperors of that time went in state to perform the due rites of ancestral worship. As we neared the tombs on our visit, the first feature we came to was a Pailow, of five gateways, in fine white marble. No one who is familiar with the gateways of the Sanchi Tope in Central India, could have failed to notice the marked resemblance. The wooden origin of its construction was palpable at the first glance. I am sorry that time did not permit of my making a sketch of this fine gateway. About half-a-mile further we passed a second gateway, but this was not a pailow: it was built in the form of a house. We passed another, of the same kind, and then began one of the noted features of the Ming Tombs, that is a long *dromos* with colossal stone figures on each side. This strange approach is nearly a mile in length. There are thirty-two figures in all, twenty of them being animals and twelve are human. They are in pairs, opposite each other, and facing the roadway. First are two griffins couchant, then two standing; two camels recumbent, and two standing; then elephants, asses and horses grouped in the same way. The human effigies seem to be those of warriors and priests. I exhibit a sketch of two of these, and their size will be seen from the figure beside one of them. They are all of stone, and although not executed in what we understand by rude art, yet they are not of a high class of work. I felt in looking at them how superior the conventional forms of Egyptian art were for such purposes. I afterwards found that a row of animals was not uncommon at important tombs. I exhibit a small sketch of a tomb near Shanghai, where a couple of horses and two griffins have been placed so as to look towards the approach to it.

On reaching the end of this sculptured avenue the Ming Tombs become visible. They are called the Shi-san-ling, or the Thirteen Tombs, for that is the number of Emperors buried at this place. They are about two or three miles away from the end of the avenue,—for it is the approach to the whole group,—and the tombs extend for some miles along the base of the hill, which forms an amphitheatre all round. My first impression on seeing the tombs,—their roofs and walls alone being visible through the trees which surround them,—was that they were country villas. I was admiring the beauty of the site, and thinking what a pleasant place it would be to live in, when I learned from my friends that they were the houses of the dead and not of the living. They have all a southern aspect, and are protected by the hills on the north. This arrangement is due to the *Fung-Shuie's* controlling powers.

Our party made for the tomb of Yung-lo, who was the first of the Mings buried here. He changed the seat of government from Nanking to Peking. His death took place in 1425, which will indicate the date of his tomb. Like other tombs in this part of China it is an earth mound, but of imperial proportions. I had no means of measuring it, but it is said to be about half-a-mile in circumference, and my own impression is that this estimate cannot be far from the truth. There is a retaining wall, crenelated, and about 20 feet high all round; judging from the surrounding ground I should say that this mound is wholly artificial. There is nothing to indicate where the interment has been. I have little doubt but there is a very large coffin, and that it is placed somewhere under the centre of the mound. There is no entrance. I should suppose that it would not be difficult for any one in Peking to get all the information as to how the interments are made, as to the coffin, and whether there is a vault, as well as regards the funereal ceremonies; which would be all very valuable as giving light on this most primitive mode of sepulchre. To the student of Indian architecture this grave heap will be of great interest as giving us almost the exact model of such monuments as the Sanchi and Manikiala Topes; which we know were developments from the Tumulus and the Cairn.

As all graves in China are places where offerings are made, they become, as it were, altars or temples. I exhibit a small sketch of a newly made grave mound near Shanghai, where the black charcoal remains of an oblation of fire will be seen. At an Emperor's tomb a temple is constructed for these ceremonies, and in the case of Yung-lo it becomes an important addition to the original tumulus. A rectangular space south of the tomb is enclosed by a wall; it is about 1200 feet long, by 500 feet wide. I am sorry that I cannot give you accurate measurements, owing to the shortness of our visit. Within this are a number of buildings,one being the finest specimen of Chinese architecture which came under my observation. The sketch plan and elevation on the wall convey a general idea of the arrangement of these structures, but I will give a slight explanation of some of them. The plan is exactly that of a Yamun or a palace; and in this I believe we have a very ancient idea which may be traced yet, that the Tomb, the Temple and the Dwelling were symbolically repetitions of each other. The House of God, the House of the Living and the House of the Dead are words which illustrate the old idea, and many evidences might be given, and the reasons which underlie it might also be explained, if that were the subject of the evening. China in her religious, philosophical and political systems brings down to us much that is primitive, and these large grave mounds are an evidence of this. In China the differences between domestic and ecclesiastical architecture does not exist. The Temple there is only a better kind of house. If it is a grand temple, then it resembles a palace, and this is the case at the Tomb of Yung-lo. I may remark while on this point of the subject that the connection between a Temple and a House is still more intimate in China. Every house in that country has its altars, thus making it a temple. The poorest house I have been into had something in which to burn incense before the ancestral tablet. Even those who pass all their lives in boats, and who are born and die on the waters—where the boat is the house—have a small portion of it set apart for the worship which it has been their custom to practice.

On the top of the wall enclosing the mound, and in a line with the other buildings to the south, there is a structure which contains what I suppose to be a monumental tablet. It is on the level of the top of the crenelated wall, and it is reached by ascending a ramp through an arched passage, which has a very distinct echo. This tablet or tombstone, for it is much like some of those we have in our own church-yards,—is a tall block placed erect on the back of a tortoise, a fashion which prevails in the case of all tombstones erected by Imperial Order or permission. In the sketch of one exhibited, the top is ornamented with the dragon, which is the great symbol of the Emperor. To the south of this is a very fine stone altar. It has upon it the five vessels which are found on all altars in China. The stones are of one piece, extending its whole length, which may be about 20 or 25 feet. Further south is a wooden pailow or gate, and then a small hall.

The next building to the south is the Great Hall, which I have already alluded to, as the finest specimen of Chinese architecture. I exhibit a photograph of it, though it will scarcely convey an adequate idea of its appearance. The rich yellow colour of the roof is lost, and the marble terraces all round are too small to produce an effect; so that in the photograph it looks like a large shed. I learned the exact dimensions of this building; it is 220 by 92 feet 8 inches. The roof is supported by sixty pillars; sixteen of which are 60 feet high, and about 11 feet 4 inches in circumference. The others are about 40 feet high. The wood is teak, and is said to have been brought from Borneo; they were made into a raft, and floated the most of the way; but there must have been a long land carriage as well to bring such heavy building materials. Although quite 400 years old, these pillars, and in fact the whole building, are about as perfect as on the day of erection. The raised stone platform, which I have already described as being the base of Chinese buildings, becomes in the important or imperial edifices a triple terrace, with a low marble balustrade. This, although now in marble, is only a repetition of an earlier wooden form, which you can easily recognize by inspecting the sketches exhibited. The space between the pillars on the south side of this hall is all of wood; I do not remember rightly about the north, but my impression is that it is of brick. It has the usual frieze, including a triple row of brackets, and the roof is like that of all other imperial structures. I exhibit a number of sketches of the interior; they are rough, but an idea of the details may be obtained from them. Some of these sketches give the construction of the roof and the connection between it and the pillars. The tendency to use brackets to give support and strength, and also as ornamental features, will be seen; this is important, as shewing the character of the original wooden basis of architecture, not only in China but in India, and other countries in that region.

The purpose of this vast hall seems to have been that of containing the Ancestral Tablet of Yung-lo, which is wood, and not above 18 inches or 2 feet high. Such a small object and such a great structure remind one of the mountain and the mouse. The inscription on the tablet was:—

The Perfect Ancestor;
The Literary Emperor.

In the last line you have one of the favourable aspects of the Chinese mind, that is a reverence for literary ability. There are the usual five vessels for incense, candles and flowers, before this tablet; constituting the whole place a temple, and in front of it we had our tiffin, and no desecration was understood to result from the act, illustrating what has been already stated in regard to the house and the temple in China. A sketch of this tablet is exhibited.

There are some other buildings in front of this, but I did not learn their purpose.

I consider that it was fortunate for me that I chanced to visit Nanking while in China; for there I saw another Ming Tomb. When this dynasty began Nanking was the capital, and Hung-wu was the first Emperor of the line. His tomb is still an object of attraction amongst the ruins of that vast city. The residence of the Court having been removed the tomb at Nanking has not been so well looked after as those at Peking; and it must have suffered during the Taeping war. I found the trenches by which Nanking was taken by the imperialist troops all about the tomb. It seemed to me as if the buildings had been burned, for the stone bases had all the appearance of having been chipped and cracked by the action of fire. Although in ruins the plan of the tomb could be easily made out. With some slight differences of detail the arrangement is the same as that of the tomb of Yung-lo. I should say that if anything the sepulchral mound is larger. This tomb is also at the base of a ridge of hills which cover it from the north wind, indicating again the influence of the *Fung-Shuie.* There is a small sketch in black and white which will convey a notion of the size of this grave mound and its position. This tomb has also an approach, bordered with sculptured stone figures, like those near Peking, and a rough sketch plan exhibited will shew the curious arrangement of this avenue. I had a Chinaman with me at this visit as guide, but unfortunately he could not speak a word of English; however, when he saw me sketching, he used the word "*loong*," and pointed to the road with its men and animals. This word, I knew, meant *dragon*, and as it is supposed to be only one of the various forms of the serpent, I became anxious to know what my guide wished to express, and I questioned him repeatedly to see if I was right in understanding that he applied this word to the long approach; I even sketched a serpentine dragon to test him, and he signified his approval of it. From this man's manner I am certain that the twisted form of the way receives from the Chinese the name of the Dragon; but whether they have the idea in this case, which has been suggested as the theory upon which the stones of Carnac in Brittany, and the avenues at Abury are supposed to be laid down, I could not say. I made enquiries on this subject while in China, but could find no one who had studied Chinese architecture from this point of view. My stay in the country was short, or I would have had this matter cleared; and I mention it here so that those who take an interest in dracontine temples, and serpent worship, may take the subject up and make further enquiries. I should be rather inclined to believe that the *loong* or dragon has something to do with it. There are few things connected with an Emperor of China but what have the name of the "Dragon" attached to them. In fact he is the "Dragon" himself; the throne is the "Dragon Throne;" the robes of state are the "Dragon Robes;" the vermilion pencil, with which he signs all the official documents, is the "Dragon Pencil." The Imperial marriage which took place when I was in Peking was called in official language "The Union of the Dragon and the Phœnix;" the last being the symbolic title of the Empress. When the late Emperor Hiengfeng died, Prince Kung announced the event to the British Minister in the following words: "His Majesty the Emperor departed on the great journey, ascending on the *Dragon* to be a guest on high." If the Dragon be thus the way to heaven, it would be quite in keeping to associate it with the visible way to the tomb. The avenue at the Peking tombs is not quite straight, but it has not the serpentine curves of the one at Nanking. The size of the figures in both cases are about the same, and the style of art is not so different as to be recognisable.

I was able one morning while in Peking to visit the Temple of Heaven; and, so far as I know, this curious shrine has not yet been fully described in our own language. I have seen Du Halde's account of it, but not the faintest notion of the place can be formed from it; and his plan of it is fanciful and inaccurate. Photographers who have penetrated to the place have always given the north altar as the Temple of Heaven, whereas it is only a portion of it, and not the most important. The few travellers who have described the place have been attracted by the building on the north altar, and have not even mentioned the south one, which I now believe to be the most important part of the whole. The Chinese themselves have written descriptions of the building which were made out at its construction, and which explain the purpose and meaning of it all. The Rev. Mr. Edkins, who is a

Chinese scholar, has drawn from this source and written a chapter upon the subject, which will be found in the appendix of a book of travels by Mr. Williamson, a missionary. I mention this as the source of much valuable information, but I could wish that everything connected with this very important temple were translated from the Chinese authorities and accessible to us Westerns.

There are in Peking a number of Imperial temples, such as the Temple of Heaven; the Temple of the Earth; the Temple of Agriculture; the Altars of the Sun and Moon; and others. The ceremonies at all these temples have no relation with any of the three religions followed by the people of China; these being the Tauist, the Confucian, and the Buddhist. The Emperor only is the Worshipper in these temples at Peking. He is not only the Worshipper, he is at the same time the Priest. It is another example of that old idea of Priest and King—of the spiritual and temporal power combined in the head of the state.

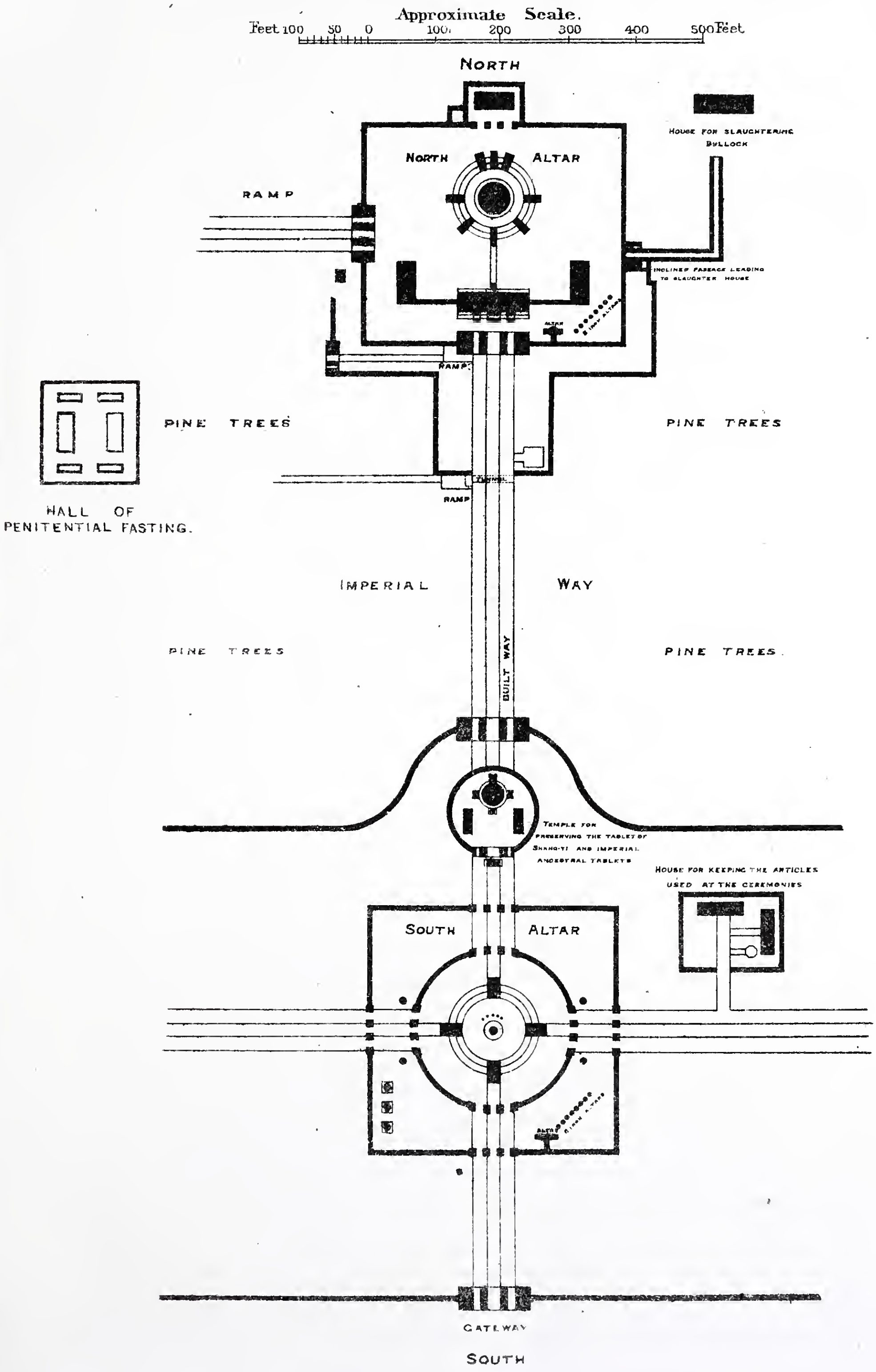
As the present Emperor has been a minor for the last ten years, the services at these Imperial temples have not been performed, or they have only been done by deputy. On the 21st of December last—that being the winter solstice according to Chinese reckoning—the young Emperor officiated for the first time at the Temple of Heaven. At the vernal equinox, the Emperor repairs to the Temple of Agriculture, and ploughs a portion of land, upon which he sows five varieties of grain. This is done as a model of industry to his people. The ceremonies at the Temple of Earth take place at the summer solstice, when a bullock is sacrificed and burned.

The Temple of Heaven occupies about a square mile of ground: that is, the outer wall is about four miles round, enclosing a large space, which has a park-like appearance, with avenues of trees. Here the animals kept for the sacrifice, find grazing. I was struck by noticing that this temple has three enclosures: whether this is accident or not I could not say. I know that the three-fold division is common to temples all over the East. We have the Tabernacle of Moses and the Temple of Solomon; and the Eastern Churches to this day follow this three-fold division. The Umbrella is an old symbol of dominion and power, and the Chatta of Buddha is triple, implying, no doubt, sovereignty over "the three worlds," which are so often referred to in the ancient classics of India. They are as old as the Ramayana. One of the most important of the insignia of the Emperor of China is a triple umbrella; and it will be seen that the circular building on the north altar of the Temple of Heaven has a triple roof. The north and south altars have a triple terrace. From this we may almost presume that the three-fold enclosure of this great temple is not accidental. The plan of Peking itself has this same arrangement: there is the Tartar city; within that is the Imperial city; and within that again, like a *sanctum sanctorum*, is the Palace of the Son of Heaven. That the Chinese do these things in virtue of symbolic ideas, may be inferred from a statement made by Gutzlaff: he says that China "is a heaven upon earth—*the Celestial Empire*. They have endeavoured to model their government after Nature, and the laws of the visible heavens. Even their military standards and royal palaces are supposed to have resemblance to celestial objects." It would have been valuable if we had this author's explanation as to how his countrymen carried out this symbolism. We are left in the dark, but we shall see as we proceed that the Temple of Heaven has a signification in almost every stone of which it is composed.

The central portion of the Temple of Heaven contains two altars, which are distinguished as the North and South. I will first describe the south altar, as I believe it is the most important part of the temple, and also because I think it will convey more clearly the original idea upon which the whole was constructed. At the first glance it would strike the observer that it was merely a platform for a band to play upon. There are three circular terraces built on each other, each about six feet high, which are

TEMPLE OF HEAVEN _ PEKING.

SKETCH PLAN OF NORTH AND SOUTH ALTARS.


Approximate Scale.
Feet 100 50 0 100 200 300 400 500 Feet
NORTH
NORTH ALTAR
HOUSE FOR SLAUGHTERING BULLOCK
RAMP
INCLINED PASSAGE LEADING TO SLAUGHTER HOUSE
ALTAR
8 IRON ALTARS
RAMP
TUNNEL
RAMP
PINE TREES
PINE TREES
HALL OF PENITENTIAL FASTING.
IMPERIAL WAY
BUILT WAY
PINE TREES
PINE TREES.
TEMPLE FOR PRESERVING THE TABLET OF SHANG-TI AND IMPERIAL ANCESTRAL TABLETS
HOUSE FOR KEEPING THE ARTICLES USED AT THE CEREMONIES
SOUTH ALTAR
ALTAR
8 IRON ALTARS
GATEWAY
SOUTH

ascended by four flights of steps, one towards each of the cardinal points. On the top of this there is no house, but only the five marble vessels, which are to be found on all Chinese altars: a canopy is erected upon occasions of celebration. Although we apply the term "temple" to this, the Chinese, as will be seen, only call it an altar. Still we might apply the old Greek term, and give it the name of a Hypæthral Temple, seeing that it has no roof but the dome of heaven above. The visible objects, to which worship is directed at this shrine, is the tablet of Shang-ti, The Supreme Lord of Heaven, and the tablets of the deceased Emperors of the present dynasty. Few temples in the world are so free from idolatrous forms as this. The Emperor prays, and offers incense, as an oblation of fire. He drinks, and eats the "Flesh of Happiness,"—almost repeating the sacramental ceremony of the Christian Church. Mr. Edkins says, "to Heaven alone is offered a piece of blue jade, cylindrical in shape and a foot long, formerly used as a symbol of authority."

There is a furnace of green porcelain below, and eight smaller furnaces of iron; and while the ceremony is going on above, a bullock—it must be two years old and without blemish—is being burned with sheep, pigs, rabbits and deer; pieces of silk are also burnt as offerings. Dancing and music are also part of the performances. The Emperor comes to the temple the night before, and fasts. The Hall where he is lodged is called the *Chai-Kung*, or the "Hall of Penitential Fasting," and the ceremony takes place at the dawn of next day. This is only a very rough outline of the ceremony; and I will now give some details of the symbolism of the construction of this altar or temple.

The four ascents, with approaches and gates to the four cardinal points, have no doubt an astro-geographical meaning. The Imperial temples of Peking have been constructed with reference to the relations of numbers, and this is more particularly the case in the Temple of Heaven: the upper circular top is 90 feet in diameter; the middle terrace is 150 feet, and the lower 210. These are multiples of 3×3=9, 3×5=15, and of 3×7=21. The number "9" figures largely in it. The ascent to each terrace has 9 steps, the whole ascent being 3×9=27; the pavement on the top is formed of 9 circles of marble slabs: the first circle has 9 slabs, the second is formed of 18, the third of 27, and so on, each circle being a multiple of 9, till at the outer circle 9×9=81 is reached,—a favourite number in Chinese philosophy. There is a central stone, and there—surrounded by these symbolic circles, with terraces and enclosing walls, and the circle of the horizon as the extreme of the visible world—a Deified Emperor seems to himself, and to his Court around, to be the veritable Centre of the Universe. With his face to the north, and assuming the attitude of a subject, he acknowledges in prayer, and by his position, that he is inferior to Heaven, and to Heaven alone. One of the statements I heard while in Peking was regarding the number of second, third and fourth class wives which would form the complete hareem of the Emperor, and, strange to say, they were multiples of 9, being 9, 27, and 81. It is rather startling to our Western ideas that a hareem and a temple should be arranged with reference to the same symbolism.

"The balustrades have 9×8=72 pillars, and rails on the upper terrace; on the middle terrace there are 108, and on the lower 180: these amount in all to 360,—the number of degrees in a circle. The pavement of the middle terrace has in its innermost circle 90 stones, and in its outermost 162 stones, thus reaching the double of 81, the outermost circle of the upper terrace. So, again, in the lower terrace, the circles increase from 151 stones, the innermost, to 243, or three times the square of 9, for the outermost."

These numbers are given on the authority of Mr. Edkins, and I will still further quote from him in relation to this temple. He says:—"It has been an aim to use odd numbers only: Heaven is odd, Earth is even; Heaven is round, Earth is square; or to use the ultimate expression of Chinese metaphysical thought, Heaven is Yang, Earth is Yin. The numbers 1, 3, 5, 7, 9, belong to Yang, Heaven;

the numbers 2, 4, 6, 8, 10, belong to Yin, Earth. In the official published accounts of the Temple of Heaven, this is set down as the fundamental principle." I quote still further from the same authority respecting the Temple of Earth, as by comparison it assists us in understanding the subject:—"On the north side is a double terrace, the upper 60 feet square, and the lower 106 feet square, and both 6 feet in height. The paving bricks are in multiples of 6 and 8: 36 and 64 are the favourite numbers, for we have now come into contact with Yin, the principle of darkness, which affects a square form and even numbers, just as in the Temple of Heaven the Yang principle was represented by roundness of form and odd numbers. The principle sacrifice is offered at this altar on the day of the summer solstice. There is, near the altar, a pit for burying a bullock. At the Altar of Heaven, when the bullock is burnt, the Yang principle in the sacrifice is supposed to go upward in smoke and flame. At that of Earth, on the contrary, when the victim is buried, the Yin principle descends in connexion with death and corruption."

I may here explain that the *Yin-Yang* are the Chinese symbolic forms of the dual powers of nature which underlie nearly all primitive worship. And it is important to find it here as the declared fundamental principle on which these temples are constructed.

There is a circular dwarf wall round the altar, with three doors at each of the cardinal points, and leading to the steps of ascent. Another low wall is beyond this again, with the same number of doors, corresponding to the others. It is between these two walls that the altars for burning the sacrifices are placed, in the south-east corner. At the south-west corner are three very long poles, which I was told were for lanterns, as the ceremony begins early in the morning before it is full day. On the north of the altar is a circular building where the tablets are preserved. From this a great built up way leads to the North Altar. On each side of this way, and all round both altars, is a thick grove of cyprus trees.

The North Altar is a triple terrace, not differing much from the South Altar. The one most striking feature is that a large circular house is erected upon the top of it. It is this which gives it such apparent importance, and has caused it to be taken by travellers as the real Temple of Heaven. Undoubtedly it is a part of the temple, but as the great ceremony of the winter solstice is performed at the other, I give it the precedence. It is called *Chi-Kien-Tien*, or "Temple of Prayer for the Year." It generally goes by the name of *Tien-Kung*, or "Heaven's Palace." The Emperor prays here once a year, offering sacrifices similar to those at the south altar. On occasions of famine, drought, or national calamity, it is at this altar he presents his supplications.

The South Altar has four ascents, with gates and ways leading off to the cardinal points, as if it were approached from the four quarters of the globe. The north altar on the contrary has only one approach, from the south; but it has eight flights of steps. This is founded on the *Pah-Kwah*, or the "eight diagrams," a symbol equally profound with that of the *Yin-Yang*, which figures largely in the ancient Chinese classical books as the basis of their religious as well as their philosophical system.

This circular temple, or palace, is a very beautiful specimen of the wooden architecture of China. I submit a rough sketch plan, and section of it. It is 99 feet high; four round pillars support the central and highest roof, which is nearly all gilt on the inside; twelve smaller columns sustain the second roof, which reaches only from the four inside pillars, thus leaving visible from within the whole height of the highest roof. Twelve still smaller wooden columns form the outer circle and support the lowest roof, which, like the second, only roofs the space between the pillars which sustain it and the circle of pillars next to them. All this wood work is elaborately painted and gilt. The tiles on the roofs are now all of a deep ultramarine blue: at first only the upper roof was of this colour, the middle was yellow, and the lower green; but the Emperor Kien-loong, who ascended the throne in 1736, changed them all to one tint. In the inside, the altar to Shangti, or the Supreme Lord of Heaven, is on the north; and the altars to the deceased emperors of the present dynasty, are on the east and west. On the occasion of my visit it was all very dirty, and the pavements of the outside were covered with grass and weeds. This was owing to the fact that the place had been unused on account of the Emperor being a minor for so many years; but workmen were busy putting it all in order for the ceremony to take place at the last winter solstice.

In my travels, temples have always been a study to me; and I feel a certain degree of satisfaction in having seen, and in being able to describe this unique place of worship at Peking. It is so new to us, and so exceptional in its form, that one feels doubtful about venturing upon any explanation of its origin. In sailing up the Pei-ho, I was struck with the seemingly endless number of grave mounds. This is peculiar to all the northern part of China. These mounds vary from a yard in diameter to that of the great tomb of Yung-lo, which, as already stated, is about half a mile in circumference. The simple grave-mound was the most primitive form of sepulchre. We know it in the present day as the "tumulus" and the "barrow." It became the "cairn," or heap of stones, and this ultimately developed itself into the "pyramid," or tomb, among the Egyptians. The "dagopa" is only another form of this development, and is only a round pyramid, for it is also a tomb, or a relic-holder; for burning the body and preserving the ashes is the characteristic of the Buddhist system. I have no hesitation in saying that all temples are founded on Tomb Worship. I am aware that this is a question upon which many varieties of opinion have been expressed; but after much travelling and study of temples, I have no doubt in my own mind on the matter. During the Crimean war I went with the expedition to Kertch; and as we sailed up the straits of that name, I remember being struck with what seemed gigantic molehills all round. They were sepulchral tumuli; and Dr. Clarke, whose works are now old, although not yet forgotten, describes them and thus speculates:—"In view of labour so prodigious, as well as of expenditure so enormous, for the purpose of inhuming a single body, customs and superstitions are manifested which serve to illustrate the origin of the Pyramids of Egypt, of the Caverns of Elephanta, and of the first temples of the ancient world. In memory of the 'mighty dead,' long before there were such edifices as temples, the simple sepulchral heap was raised, and this became the altar upon which sacrifices were offered." The writer is here mistaken in his reference to Elephanta; it is a Brahminical temple, and the temples of that religion are in one sense an exception to the rule here laid down, and yet, I think, not altogether so when properly understood. In India we have to do with the Aryan; in China it is the Turanian race, and among them the tomb-temple theory seems to have no exceptions. Readers of Mr. Fergusson's writings will be familiar with this subject.

The theory I would suggest is, that the Temple of Heaven in Peking, is made in imitation of a sepulchral mound. It would be important to know if any one was buried there, or if there is any tradition as to relics of a human body having been deposited—a point on which I have no information. Still, without this, if its origin has been as here suggested, it may be considered as a symbolical tomb; the architectural features upon it being a growth, and repeating in another way the development already described in the Pyramid and the Dagopa. The south altar is named in a manner to confirm this. None of the Chinese words which signify temple are applied to it. It is called *Tien-Tan*, or "Heaven's Altar;" but in the oldest times it was called *Nan-Tan*, or "South Mound;" and *Yuen-Kieu*, or "Round Hillock." These names in themselves seem to indicate the original character of this temple. and as it were exactly repeat Dr. Clarke's words, that "the simple sepulchral heap was raised, and thus became the altar upon which sacrifices were offered."

I think that a confirmation of this theory may be derived from the plan of the South Altar. The ordinary grave mounds in the north of China, where they are in their complete form, have a square platform of earth on which the mound is heaped. I exhibit a sketch of one from near Shanghai; it was newly made when I sketched it, and so the design is not lost through time, or from vegetation growing over it. There the square platform and the mound can be seen and understood. Now almost every Chinaman has read the classic books of his country, and he is aware that the square form symbolises the *Yin*, and that the mound also symbolises *Heaven* or the *Yang*. We have the statement from the Chinese authorities who constructed the Temple of Heaven, that it represents the *Yang*, and we can see from the plan that it stands in a square enclosure, giving us the *Yin* form; and thus realizing the whole principle upon which a Chinese grave is arranged.

An essential part of the temples of China is the tablet with the name of the god to whom the temple is dedicated, and before this is a table with five vessels. The centre one is for incense, in which what we call "joss-sticks" are burned, but the Chinaman in his flowery style, calls them the "Fragrance of an hour." The vessels on each side of this are for candles, and the other two are for flowers. A clerical friend has informed me that this is exactly what the Church of England permits upon an altar. Incense may be used, but it must be in a stationary vessel; two candles may be upon the altar, and flowers are not objected to. It is curious that east and west should be so close in their ritualistic rules; for it can only be by an accident that it is so. I may also mention that the theatre is still a part of the temple all over China. Every temple has not got a theatre, but the conjunction of the two is very common; and affords an illustration of the retention of ancient forms, a tendency which is perhaps more marked in China, than in any other country in the east.

The official residence of a mandarin, or a court of justice, is called a *Ya-mun;* and *mun*, the second syllable of this word, means "gate." I tried when in China to discover why this was so, and what were the ideas of the Chinese themselves, but could get no information. I naturally thought that it might be some remnant of the old idea of the king or judge sitting in the gate, and judging the people. I have described to you sepulchral monuments such as they are when ordered by the Emperor. I have now to describe another kind of monument, which are so common in China, that you can scarce move without seeing one, or the fragments of them which time has left. They are called "Pailows," and are in the form of a triple gate. They are generally put up as a reward of virtue, or good deeds, most usually they are erected in honour of virgins, or of virtuous widows, who have not married a second time. The word Pai-low has two syllables, the first means board or stone slab, and the second means upper story; so that the word is derived from the inscription being upon a slab between the upper lintels of the gateway. Although now generally constructed with large slabs of granite, the original wooden model is so exactly repeated, that we need have no doubt as to what it was; and the perfect identity of construction between these Pailows and the gateways of the Sanchi Tope, which is one of the oldest architectural erections in India, would seem to indicate a closer connection among the races in that part of the world than we have yet realised. I exhibit a picturesque old Pailow from Nanking, which will explain this wooden construction. You will see that the stones have been mortieed into each other as if they had been logs of wood. In the photograph of the south altar of the Temple of Heaven three of the gateways will be seen, and the wooden construction will be evident. I exhibit a small sketch from the native town of Shanghai, viz., the base of one of the supports of an old Pailow. A fragment only remains, but it shews one of the features of the wooden prototype of Chinese architecture. Its right name would be a truss, but I think "base-bracket" would better express its real character. It is one of the marked members of nearly all Chinese architecture, and you may recognize it in the photographs and sketches exhibited. There is one photograph with a form of the Pailow common in the streets of Peking; with the exception of a marble base for the pillars and the tiles, it is all of wood. The peculiar bracket-frieze, which is almost lost in the shadow, is, as I have already stated, one of its most prominent features. There are two photographs representing another style of Pailow peculiar to Peking; and a very beautiful style of work it is. The base and arches arc of marble; the base mouldings are formed upon the Lotus-throne of Buddha, indicating an importation from India—a portion is of brick, but the upper part of coloured majolica. In these photographs you will see the bracket-frieze repeated in that material. You will also see that the wooden pillars, beams, and brackets are repeated; that the arch is an insertion, and perfectly foreign to the original style. In buildings about Peking this arch is not uncommon. Mahomedanism we know spread eastward as far as China, and we may suppose that the arch came with it. The followers of the Prophet took it into India, and we know of no other source from which it could come to China.

There is a very fine old arch in the village of Keu-yung-Kwan, in the Nan-Kow Pass, on the way to the Great Wall, its date is said to be 1345. It is a triumphal monument erected in memory of a victory. There is a photograph of it on the wall, with a slight sketch showing the voussoirs, of which there are eleven in all. One striking peculiarity is, that the inside of this arch is cut into three plain surfaces; these surfaces being elaborately sculptured with Buddhist figures. This monument has great importance to philologists, because there is an inscription repeated in six different characters. The first is in Sanscrit, and that is copied phonetically in Thiketan, Mongolian, Ouigour, Neuchih, and Chinese. The Mongolian character is a very rare one known under the name of Bashpah, and some of the letters were uncertain till this inscription was found out. The Neuchih alphabet was only known by name, but now a complete knowledge of the characters has been framed from this arch, hence it is a sort of Rosetta Stone to this part of the world. Mr. Fergusson has shewn me the photograph of an arch from Khatmandoo in Nepaul, in which the sculpture and ornaments bear much resemblance to this. In the Nepaul example the figures on the key-stone is Garuda, the Wahan of Vishnu, and it bears a marked similarity to this one in China. The figures on each side of the key-stone are sitting upon serpents, whose seven heads surround like a canopy, or glory, the heads of the figures. This is so purely Hindoo, that I think we need not hesitate to suppose that it came to China by way of the Himalayas. I have not seen or heard of any erections like this arch in any other part of the country.

I need say little about the Great Wall. The portion of it we saw at the north end of the Nan-Kow Pass, is in very good condition. It is built of solid stone, with brick parapets. Huc and Gabet describe it farther west as being little better than an earthen parapet with a ditch, and so unimportant that they could ride over it. In some places it is only rude stones heaped up. It is said to be 1200 miles long. Mr. Seward, who had visited the Great Wall shortly before I was there, estimates that the labour employed on it would have made all the railways in the United States. And Barrow, who went with Lord Macartney's expedition at the end of last century, computes that the building of all the houses at that time in England and Scotland would not be equal to the labour required for the Great Wall.

The wall which forms the inclosure of the City of Peking is much more imposing to the eye than the so-called Great Wall of China. There are 16 miles of it enclosing the Tartar eity, and one 9 miles more round the Chincse city. It varies from 30 to 60 ft. wide on the top. It would form a magnificent street, but no one is allowed to go upon it, and the result is, that grass and bushes are growing like a thick jungle. The bricks of which it is built are 19½ inches long, 9¼ inches broad, and 5 inches thick.

I come now to the particular kind of building which we associate more than any other, with the architecture of China, and that is the Pagoda. The Chinese apply the word *Ta* to these buildings. The origin and purpose of these erections seems to be about as puzzling as the Round

Towers of Ireland. We know the purpose for which some were constructed. The celebrated porcelain pagoda at Nanking was a monument of gratitude; others are monuments of victory. Generally they are beside temples or monasteries; but often they stand alone. This variety shews that they have no definite idea attached to them, and that whatever may have been originally their meaning, it has been entirely lost. I made a few enquiries regarding them when in China, but nothing could be learned. Those I spoke to seemed to accept the statements of the Chinese, who believe that they came from India. I visited one at Peking, called the *Tien-ling-ssŭ*, and which I was assured was built after an Indian model. I exhibit a very rough sketch of it. It is of brick and wood, with stone in the lower parts. A photograph on the wall of the Pah-li-chwang pagoda will supply the character of the details, for the two are very similar. They have both thirteen roofs, each roof becoming a cornice, with the bracket construction arranged as a rich frieze. The sculptures are Buddhist figures and serpents. So far as I know there are no such buildings in India: we have no remains of such, nor have we any representations of them in the old sculptures of that country. Therefore, if this kind of building came from India, it must have undergone some very considerable modifications during its journey to China. I have talked with Mr. Fergusson as to what might be possible as an explanation, and he has made what I think is a fair suggestion:—that the Pagoda is the Dagopa with the Tee developed into a tower. The chattas or umbrellas may have become roofs. We have indications of this development even in India itself. A triple umbrella was the usual object over the Chaitya or Dagopa, but there are instances were the umbrellas are of a greater number, and almost assume the character of a tower. There is a sculpture of a large Dagopa at Amarvati, where the sky above is filled with Chattas. In the Burmese Dagopas we find that the form has got elongated. There are true Dagopas to be found in China, but they are after the model to be found in Tibet at the present day, so we may presume that they came overland; and if we adopt the idea that the Chinese Pagoda is a development of the Indian Dagopa, the probability is that it came round the other way by the sea; receiving a modification from each country and race as it travelled along. Until recently there was nothing Indian about it, except the Buddhist figures, and perhaps the lotus leaves which generally figure about the base.

At Chinkiang, on the Yang-tse-Kiang, I visited an old iron Pagoda, and having a friend with me who could speak the language, I managed to get some curious information out of a Buddhist priest that we met there. The information is of a kind, which I think would have delighted the hearts of the old writers on the Irish Round Towers, and would have established to their satisfaction that the Pagoda was nothing more nor less than a copy of these old monuments. I was sketching—the result is upon the wall to night—when this priest chanced to pass. He stopped to see what I was doing, and I asked my friend to enquire if he could explain the peculiar hieroglyphic-like ornament. "Ask him," I said, "if that moulding next the ground is water?"—"Of course it is," was the answer. "Is water not the *Yin?*" Naturally we had no objection to offer to this interrogation; so I directed another question to the next moulding above. "Are those clouds?" and he said "of course, that is Heaven; and is Heaven not the *Yang?*" I saw that he was treating us with contempt, but I felt the value of his information, and he was just going off with the remark that there was no use in explaining such profound subjects to "Outer barbarians" like us, when I got my friend to ask if the octagonal plan of the Pagoda was founded on the *Pah-Kwah*, which he admitted was the case. He then left us with as much of the air of proud disdain as a Chinaman can assume. Seeing that I repeat this here to night, if my Buddhist friend, could be made aware of the fact, it would be some consolation to him; and he might begin to believe that there was some use in the information he gave. I cannot tell whether this priest was an authority or not, but I give you what he told me, and on the walls you will see the sketches which illustrate his words. The Pagoda is about 30 feet high—all of iron. Notice that the bracket construction is repeated. There are seven stories on it, and I am told that it is as old as the Tang Dynasty, which is A.D. 618 to 923. It is supposed to have been erected as a mark of the boundary between two kingdoms into which China was divided at that time. Here again is another purpose of the Pagoda, shewing what I have already mentioned, that it is a sort of "Jack of all trades." I exhibit a fragment of one of the porcelain bricks from the celebrated Nanking Pagoda. It was erected, in the early part of the fifteenth century, for an Empress, and I think she most likely was the wife of Yung-lo; so it dates very nearly with the Ming tombs. It was 236 feet high and of nine stories—pagodas are always in stories of odd numbers—that is *Yang*. I visited it last December, and a mound of rubbish is all that is left, and from this I managed to pick the fragment of a brick, and a bit of tile. Nanking suffered very much during the Taeping War, and I believe that the pagoda was entirely demolished at that time.

On the wall is a sketch of the White Ming Pagoda at Peking, a very literal imitation of a Tibet Dagopa which has come to China almost unchanged. I also exhibit a sketch of a Dagopa at Chingkiang, which is built over a lintelled way. The base of the Dagopa and the lintelled way is so purely Hindoo, that I feel very puzzled as to an explanation. I tried to get the history of this work, but my movements in China were so very hurried, that I was unable to learn anything about the origin of the monument. It is almost free from any Chinese influence.

In conclusion, I would say that to one who is intimate with the architecture of India, that of China seems poor in comparison. And yet it is important from its links of connection, and as illustrating a similar wooden development, more particularly the bracket, which, as a wooden piece of construction, became in both cases an ornamental feature of the architecture. The original architecture of India was wooden, like that of China, and we can only guess at what it was by the stone reproductions which exist. The enquiry is interesting, and if this paper supplies even a mite to the elucidation of the subject, I will feel that I have added a stone to the cairn, and will be content. My own impression is that this paper is more valuable in an archæological than in an architectural sense, but I know that every day is making the study of architecture more and more important as a branch of ethnology, and as such I submit it to your consideration.

It may interest architects in this country to know how money is raised in China for building purposes. In the streets of Peking I one day found a man in a sort of wooden sentry box; large nails had been driven into it, so that their points projected through: this prevented the man from leaning against the sides, and the only rest he had was from sitting on a board within. He was a monk, and never seemed to sleep, for he had a string with which he night and day sounded a large sonorous bell every few minutes, as a sort of advertisement of his purpose. This was, that the benevolent should come forward with money: each nail represented a sum; when any one paid that sum his name was stuck up on a bit of paper, and the nail was pulled out, making it more comfortable for the hermit within. All the nails represented the necessary amount for the repair of a temple which was close behind. This is a common means of "raising the wind" for such purposes. I was told that this monk had been two years shut up, and that he would likely be another year before he got out of his cocoon of nails.

On the walls will be seen a sketch of this house and the bells; also a sketch of one of the idols in the temple, which you will see are sadly out of repair. I have traced the Architecture of China back to a wooden construction; and in that sketch you will see that the gods of that country, from the joints and sockets of which they are made, may, at least in some instances, be referred to a similar origin.

The CHAIRMAN.—Seeing my friend Major Crossman, of the Royal Engineers, present, I am sure we shall be pleased to here any remarks from him on the subject of this Paper: and I may add that we are indebted to him for the valuable collection of photographs exhibited here this evening.

Major CROSSMAN, R.E., said,—I have some other plans of Chinese buildings which I should have been glad to have placed before you, but they are in the country. My friend Mr. Simpson has given you a good description of all the general features of Chinese architecture; but I have seen one or two things which perhaps did not come under his notice. He has told us of the great Ming tombs at Peking and Nanking, but I may just mention the tombs at Foochow, where many of them are dug out of the hill-side in the shape of a horse-shoe. In many instances figures of lions and dragons are beautifully carved on them; the effect thus produced being often very beautiful. The ancestral tablets which Mr. Simpson speaks of are found all over the hill side; and the position of this great burial place would lead to the belief that the Chinese at least do not regard intramural interments as being so unhealthy as they are supposed to be by ourselves. I may mention one fact with regard to the tombs at Nanking. My visit to that place was, I believe, two or three years anterior to that of Mr. Simpson. I walked through a great portion of that enormous city, the walls of which are thirty-eight miles round. It had been nearly destroyed by the rebels, and nothing but mud hovels and temples remained. With regard to the shape of the road being like a dragon, I refer you to one of the lower plans on the wall, which certainly bears out the idea. After travelling some distance along that winding road, we came to the ruins of temples, with pailows, and we noticed the marble foundations of old enclosures round fish-ponds; after which we passed between the figures of camels, horses, dragons, elephants, warriors and priests, which Mr. Simpson described. We came at last to a large brick tower,—the only one of the kind I saw. Behind this tower was an immense mound, beneath which were said to be the graves. The custodian of the place refused to give us admission into it, but we were led to believe it was a place of sepulture; and in that point of view it possessed no inconsiderable grandeur. Mr. Simpson has described the great wall, the temples, the pagodas, and the pailows. The latter are met with in considerable numbers in Peking. On making enquiries as to their history you are generally told that they are memorials of widows who never married again; in fact, they are memorials apart from the tombs. I may mention that those large open spaces under the handsome roofs at the Peking Legation, shown in Mr. Simpson's drawings, I managed to make into comfortable rooms looking into an inner quadrangle by building up the side walls, and by utilising the old ornamental tiles, the general appearance was not impaired. With regard to the origin of Chinese architecture, I agree with Mr. Fergusson, who explains in his book that it was not, as commonly reported, founded on the shape of a tent; but that the high-pitched roof, covered with tiles, was made to carry off the heavy rains. Now, if the high pitch had been continued down to give shade from the summer sun, the upper rooms would have been very dark. They therefore shaped the eaves in this way (illustrating on the board), and, by doing so, obtained, in a graceful form of roof, shelter from rain and sun. Chinese architecture is very similar to that of Japan. It is simple, and the work is for the most part very well done. With regard to the execution of building work in China, I generally found honest people to deal with. One difficulty was their system of guilds, or trades-unions, which is carried on there to as great an extent, if not to a greater, than it is in our own country. If you dismiss a man, there is a chance of all the rest striking. At the time I was engaged in erecting some buildings at Foochow, I found that the Canton merchants were building a magnificent guildhall, the brickwork of which was as fine as any I ever saw in this country. I could not get the people to do the same kind of work for me, although I employed the same contractor. On asking why, the reply was that the mandarins would not let them do it for a foreigner; and it was only with the greatest difficulty that I could ever get anything like the same kind of work done for me as was done for their own people. At Shanghai I was particularly struck with the very beautiful character of the granite work. The stone is cut with a cold chisel, without the use of a hammer. It is true, the men take their own time over the work, and stop every few minutes to smoke their pipes and take a cup of tea; luckily grog is unknown to them. I do not know that I can add anything more, except with regard to the engineering works. Some of the bridges across the Grand Canal are very fine. They are generally of that type which is rudely depicted on the willow-pattern plates; but some of the arches are very well built. The stones are all cut properly; and although we should consider the form of the bridges very inconvenient, they are very correctly constructed, and have a very nice appearance. The Canal itself must have been a great work. It was cut across a flat country many hundred years ago, and apparently nothing has been done to it since. The roads are made with solid masses of granite, and have evidently never been touched since they were first constructed. The Commissioners of Public Works, as they may be called, are supposed to receive large sums of money every year, which, it is to be presumed, they put into their pockets. Going from Peking to Tangchow, there is a road which has been travelled over for several hundred years, and that road I suppose has never been touched in the way of repair all that time; and I remember to my cost the shaking I got when I was obliged to travel in a springless cart over it. Under the very gates of Peking, in the archways, there are ruts in the granite roads two or three feet deep. How the carts go over them at all is a wonder. In conclusion, I will only say that the architecture of China must have been, like everything else in that strange country, at a standstill for many centuries. It is to be hoped that they will advance in that as they are now doing in other things; but it will require a long time, for they are a people who cannot be forced or hurried in anything.

Sir DIGBY WYATT,—Our time being short to-night, I will only in the briefest manner propose votes of thanks to Mr. Simpson, and also to Major Crossman, R.E. The former gentleman presents in himself a remarkable refutation of the old saying, " a rolling stone gathers no moss," since Mr. Simpson has rolled to and fro through the world, in almost every quarter of it, and I do not know anybody who has brought home more " moss," or of better quality than he. We find him at one time in India making magnificent drawings for Messrs. Day and Sons' projected and partly completed work brought out under the editorship of Sir John Kaye. We have met, and happily still meet with his illustrations, and recognise his brilliant touch, week by week, in the pages of the " Illustrated London News." We have shared in his Crimean experiences recorded on stone and wood; and, in fact, we may say we are familiar with all his works, for we know where he has been and what he has been doing at almost any time, in almost every way, through many years of his active life; and the more we know of him the more we respect him. It is very delightful for us as architects to find an artist—a pure artist and painter—who can travel so much about the world, and interest himself as much as Mr. Simpson has shown us he does in our art, not only as to its picturesque aspect, but in its constructive and archæological conditions. We owe him a sincere debt of gratitude for his preparation of more than one well illustrated and eloquent Paper for this Institute. He has done to-night with respect to the sections of Chinese architecture, of which he has treated, what other artists and architects have done in connection with other branches of the subject. Who can forget either William Alexander's brilliant studies for the illustration of Lord Macartney's embassy; or Thomas Allom's beautiful drawings for Fisher's " Picturesque China?" Allom devoted himself to the illustration of a branch of the subject on which Mr. Simpson has not had time to dwell to-night, and showed us some leading characteristics of the ordinary dwelling houses of the Chinese, which to my taste better illustrate the genius and habitual instinct for ornamental art of the people we have been considering than do their larger monuments, which have rather an archæological and ethnological interest than a strictly architectural one. Many of us may recollect the small models frequently brought, especially during the last century, from China, and occasionally made of precious materials, as were the fine specimens which used to be in the old India House Museum. (Where they are now I cannot say, but they were exceedingly interesting). There are others of the same description in the "Maurits Huis" at the Hague, some of them showing how much the Chinese rejoice, and how well they succeed in garden architecture, and in those features of design which so much delighted Sir William, then Mr. Chambers, as testified by his work on Chinese architecture, published in the middle of the last century. The illustrations before us this evening of the open pierced work of windows and panels founded on the Indian Jali are extremely interesting, and to practical architects convey much suggestion. I hope some day we may have from Mr. Simpson a paper and illustrations upon the domestic architecture of the Chinese. (Cheers.) Before sitting down, I must remind you that it is our duty, I think, to include in our thanks my friend Major Crossman, of the Royal Engineers, an old and esteemed colleague of mine in the superintendence and partial contrivance of the Exhibition building of 1851. Since that date he has been to my knowledge a most industrious practiser of our art, if not a professor of it, as an active officer of Royal Engineers, in all parts of the world, as the motto of the corps demands, "Ubique quo fas et gloria ducunt."

Mr. E. I'ANSON,—I have great pleasure in seconding the proposition of Sir Digby Wyatt; and I hope this paper, which is one of great interest, will prove the precursor of others on the same interesting subject. I should like to have heard from Mr. Simpson a little more about the permanence, or want of permanence, in the style of architecture in China. I gather from the paper that the same style is used in all the buildings, from a dwelling house up to the temples, varying in that respect from our own architecture and that of the Greeks and Romans. We hear from Major Crossland that architecture in China has been at a stand-still, as I understand him to say, for several hundred years. Was it permanently the same style, for several hundred years, antecedent to that, or were there gradations of style, and variety in the style of the several dynasties which have existed in China? With regard to Chinese decoration, one gentleman has told us that the buildings are decorated in some portions with elaborate fret-work. Where there is detail there is room for difference of ornamentation. In Chinese ceramic decoration we see there is unquestionably considerable traces of Greek ornamentation. Did the Chinese become acquainted with Greek art, or was it an original style of their own? How old are their first architectural works? and have they been consistent in style from remote antiquity up to the several hundred years referred to, during which it has been at a standstill? and were the same typical features adhered to throughout? or were they influenced by the incursions of the Tartars and by their own commercial intercourse with other countries? These, I think, are points of interest, and looking upon this paper merely as a preliminary one, we may hope at some future time to acquire more knowledge than we now have on the subject of Chinese architecture. I cordially concur in the vote of thanks which has been proposed.

The CHAIRMAN,—It is my pleasing duty to put to the meeting the proposition, in the first instance, that we thank Mr. Simpson very cordially for his contribution to our Sessional Papers; and, secondly, allow me to ask you to do the same to Major Crossland, who has so kindly come forward to give us the benefit of his information on the subject.

The vote of thanks was unanimously passed, and the Meeting then adjourned.

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 15th of December, 1873,
Horace Jones, Esq., Vice-President, in the Chair.

PRESENTATION OF SIR CHARLES BARRY'S BUST.

(Executed by J. H. Foley, R.A., and given by J. L. Wolfe, Esq.)

The preliminary business having been transacted, and the Marble Bust of Sir C. Barry presented by Mr. J. L. Wolfe having been uncovered,

The Chairman said he was sorry to state that Professor Donaldson, who had promised to attend the formal presentation of the bust to the Institute, was prevented from doing so by illness, but he had requested Professor Kerr to make a few remarks in his stead; and that gentleman had kindly consented to do so.

The Secretary then read the following letter from Mr. Wolfe:—

"Great Western Hotel,
"13th December, 1873.

"Dear Sir,

"With your letter came one from Professor Donaldson, telling me what I was grieved to learn, that he was confined to the house by illness. As neither he nor I can attend your Meeting on Monday, you will please to explain that the Bust of Sir Charles Barry was ordered immediately after the completion of the Statue, but it was only recently that Mr. Foley informed me it was ready for delivery.

"I now beg the Institute to accept this Bust of their late distinguished Fellow, as an acknowledgment on the part of one of his oldest friends of the Institute's invaluable aid, not only in obtaining the requisite funds, but in securing the erection of the Statue in the fittest place for the Memorial of an Architect, within the walls of his greatest work.

"I am, dear Sir, yours respectfully,
(Signed) "JOHN L. WOLFE.

"Charles L. Eastlake, Esq.,
"Secretary Royal Institute of British Architects."

Professor Kerr rose and said: Mr. Vice-President of the Institute and Gentlemen.—I am quite prepared to forgive you if you think there is something not altogether appropriate in my coming before you this evening in the capacity which I have assumed, but I have only to excuse myself by reminding you of what has already been stated, that our dear old friend Professor Donaldson has laid his commands upon me,—commands which I have always been, when possible, ready to obey. It is just thirty years ago—if you will allow me to speak of myself for a moment—within a few weeks, since I first came to London from a remote part of the country, a very raw lad, to push my fortune, as my countrymen are wont to do. At that time, although I knew very little of the profession, I remember I was able to take considerable interest in what was going on; and what attracted my attention more prominently than anything else was a group of four distinguished men, who have been ever since, as leaders of the profession, the idols, so to speak, of my professional life. These names were Cockerell, Donaldson, Tite, and Barry. In Cockerell we had a man of infinitely delicate refinement; a gentleman such as we seldom see; an architect who did honour to every touch of his pencil, and who derived honour from every work he performed. In Tite we had a man strongly contrasted with him of whom I have just spoken, and possessing the grand, massive, muscular intellect of a man of the world, not devoid of artistic aspirations in his early youth, not devoid of learning, but having—as City men do—coolly consented to sacrifice a great deal of his intellectual pretension for the sake of the particular worship so all-important in the City,—that of pounds, shillings and pence. In Donaldson—(not to say much of him who happily is still with us)—we have a man possessed of those graces of personal character which enabled him to do more than all other men put together to consolidate the profession in that manner in which it now exists, and which alone enables us, I venture to think, to resist certain attacks which would otherwise be very difficult to withstand. Lastly, in Barry, we had the supremely successful worker,—a man of few words but of constant work; a man who, beyond all others, was manifestly destined to be the leading practitioner of his generation. To those four men there has never been, in my mind's eye, added a fifth; and now there never will be. Now, it strangely happens—if you will excuse me for still one word more with reference to myself—that I have been the humble means of presenting to this Institute memorial likenesses of all those four great men. When Professor Cockerell retired from his Presidency of the Institute, it happened to be suggested by me, as it might have been by a score of others, that his portrait should grace our walls; and I was honoured in being permitted to take charge of the matter of funds, which led in the end to my making the official presentation of the picture. Again, when Sir William Tite retired from the same office, and was considered to have deserved especially the acknowledgment by the Institute of the great liberality with which he had acknowledged the honour conferred upon him, it was determined that his memory amongst us should be preserved by a portrait; and I was entrusted with the task of procuring and ultimately presenting it. Then, again, when the portrait of my dear friend Professor Donaldson was procured on the same ground, together with that of Mr. Beresford-Hope, by the accident of my friend, Mr. C. C. Nelson, not being able to attend, I, having been in some measure associated with him at the last in the proceedings for obtaining those portraits, was called upon formally to present them to the Institute. And now, by the merest accident in the world—because of the fog of last week having unhappily attacked the throat of our distinguished friend Professor Donaldson—I am here once more, as I am afraid, a very inadequate representative of our excellent friend, to present, on behalf of Mr. Wolfe, a portrait Bust of that most illustrious of modern architects—Sir Charles Barry. Passing from the contemplation of the group of four great men I have mentioned to that of the one whose memory is our particular theme to-night, I must confess that I am quite unable to provide words or even thoughts which would express what I should intend and what you would expect. But I will say this: that at a time when our profession has become vastly extended, and consequently in a condition of no little disquietude and discomfort; when criticism may be said to be in a great measure laid on the shelf; and when the doctrines and principles of our art have been to a great extent superseded by specious fallacies and unintelligible mysticism;—there is no text upon which I would rather dwell in preaching a sermon to young architects than the life and career of Sir Charles Barry. I have said he was a man of few words: I mean with reference to professional controversy; and I may say he was in that sense a man of no words at all. He was all work, and had no time for words;—for that description of talk which perhaps at the present day occupies too much of our time. Sir Charles Barry may be said to have had his pencil always in his hand. The gracefulness which was so particularly characteristic of his genius flamed in a perpetual stream from his intelligence. And so hard-working was he, and so much did he find to do, that I am told he supplemented the short hours of the day with the long hours of the night; and, as if he had never done enough within the reasonable limits of sunlight, would sit down in silence and in solitude, when all the rest of the household were in bed, and, with that most prosaic of all artistic apparatus—the drawing board and square—laboriously working through the long hours of darkness, would be able, before seeking repose in the broad daylight in the morning, to deposit upon the desks of his assistants, as their tasks for the day, works of art that not only delighted but astonished them. Many of us remember the morning when the flag of England first floated from the glorious summit of his Victoria Tower. It was half-mast high; for the architect had died in the night. But if the flag was at half-mast, it was none the less a signal of fulness of triumph: for he who was dead had completed his work. He had stepped from his chariot in full career. He had conquered to the uttermost limit the whole province of his glory. I cannot help thinking there is something peculiarly appropriate in what we call sudden death as the end of a man of this mark. It is more appropriate, surely, than to linger through old age. And when BARRY thus died, one could scarcely help reflecting that if, as it is said, "Those whom the gods love die young," so also we might add, fortified by a multitude of illustrious examples, "Those whom the gods admire die in their harness." Sir CHARLES BARRY died, as he had lived, all in his harness; and if I may change, for a concluding word, the point of aspect of my subject, I will ask you to permit me to quote the generous and cheerful words of the Muse:

"Life! we've been long together,
Through pleasant and through cloudy weather;
'Tis hard to part when friends are dear;
Perhaps 'twill cost a sigh, a tear:
Then *steal* away,—give me no warning;
Choose thine own time:
Say not 'Good-night!'—but in a brighter clime
Bid me 'Good-morning!'"

The CHAIRMAN.—The brief but excellent address which has fallen from Professor Kerr, is so perfect in itself that one thing alone remains for us to do—is to request the Secretary to prepare a letter communicating the hearty thanks of this Meeting, and of the Institute generally, to Mr. Wolfe for his handsome donation of this splendid bust. I am happy to see present two of the sons of our distinguished friend, and I am sure we should be pleased to hear a few words from Dr. Barry.

Mr. THOMAS MORRIS, Associate, having referred to the long and close friendship which had subsisted between Sir Charles Barry and Mr. Wolfe—

The Rev. Canon BARRY rose and said,—I had no idea of appearing here in any other aspect than as a spectator and an auditor: but, as you have been pleased to call upon me I respond in order that I may state that what has just been said by Mr. Morris is perfectly and literally true. My father had one great friend through life—Mr. Wolfe. Throughout the whole of their lives I believe their friendship was absolutely unbroken. Mr. Wolfe himself was originally intended for the architectural profession, but circumstances led him into another path of life, perhaps less congenial to him, but his intimate friendship with my father never ceased. If there was one qualification in which Mr. Wolfe was more eminent than another, it was that which was most valued by my father, viz., clearness of observation and delicate and artistic criticism. No one could have desired more assistance than that which my father received from Mr. Wolfe, not only in the unbroken friendship, but in the remarkable power that Mr. Wolfe brought to his work. As I had the task of preparing my father's Life for the press, I may say there are some passages of that memoir over which we lingered with a certain pride; some, perhaps, that were traced with regret and others, with a touch of indignation; but there is no passage over which we dwelt with so much pleasure as that which commemorated the kind appreciation and generous support, in evil report and good report, which my father had the happiness to receive from the Institute of British Architects.

ON THE CHATEAU OF PIERREFONDS, AND ITS RESTORATION BY M. VIOLLET-LE-DUC.

By R. PHENÉ SPIERS, Associate.

THE complete restoration of a feudal chateau of the Middle Ages, with all its outworks, drawbridges, posterns, towers, curtain walls and interior disposition, at a cost of five millions of francs (£ 200,000.), is a work of so unusual a character, that I have ventured to deem an account of it worthy of the attention of the Institute this evening.

I could wish that the subject had been treated by some one whose studies had been more directly devoted to the military architecture of the Middle Ages, for I am able to lay claim to no special knowledge beyond that which a careful examination of the chateaux of Pierrefonds and Coucy have afforded me, assisted by the excellent pamphlets published by Monsieur Viollet-le-Duc and the free permission to inspect the whole of the building, and to draw when and where I pleased. I was fortunate enough also to meet M. Viollet-le-Duc on my visit there in September this year, and to obtain from him much valuable information, and the gift of the autograph drawings made for the restoration of the chateau, which, with some photographs and a few sketches, enable me to illustrate, and I hope render more interesting, my paper this evening.

The work of restoration was commenced in 1859. There had been, I believe, at first some intention of restoring the chateau of Coucy, situated some sixty miles to the north-east of Pierrefonds, but the distance of the former from the capital, and the fact that the chief motive in the restoration of one or the other was the intention of the Emperor to reside there, led to its being given up in favour of the latter. The proximity of Compiègne, which was the summer residence of the Emperor, and more especially the opportunities for sport afforded by the forest, which lies behind that town and Pierrefonds, probably confirmed the Emperor in his choice.

As far back as the ninth or tenth century the site now occupied by the chateau had been selected as a military position. The only remains, however, of any building prior to the commencement of the sixteenth century, would seem to be traces of walls of the twelfth or thirteenth centuries, and a postern gate of the latter end of the twelfth century. Towards the close of the twelfth century, and shortly after the extinction of the race of the lords of Pierrefonds, the old chateau was purchased by Philip Augustus, and given by him, in 1215, to the monks of St. Sulpice.

In 1390, Louis Duke of Orleans, and brother of King Charles VI., pretending that he was being deprived of his rights as Regent, obtained possession of and fortified various positions in his Duchy of Valois. He bought and rebuilt portions of the chateau of Coucy; restored Bethisy, de Crespy and de Montepilloy; reconstructed the chateaux of Ferté Milon, Vez and Loge Lambert; and set to work to erect the magnificent chateau which has just been restored by M. Viollet-le-Duc. Its position was chosen as well from a military point of view as for the same reason which led to its selection by the late Emperor: viz., the proximity to Paris, and the facilities for hunting, sporting and fishing afforded by the neighbouring forest of Compiègne. M. Viollet-le-Duc, in his pamphlet, enters into detail on the strategical points of value afforded by the chateau; which, however, I have not deemed of such immediate interest as to be entered into now.

Notwithstanding its strong power of defence, the chateau was taken or given up several times: first, to the Count of St. Pol-en-Valois, by whom it was fired; but restored by the Duke of Orleans shortly after. In 1420 its doors were opened to the English. In 1422 it was in the possession of the

Dauphin. Later on Louis XII., when Duke of Orleans, made some additions, but of a slight nature, as the main block of the chateau, before its restoration, belonged entirely to the commencement of the fifteenth century; and we do not find, as at Coucy (also restored by the same monarch), the somewhat debased details of the end of the fifteenth century.

In 1593 it was besieged by the Marechal Biron, under orders from Henry IV., but without any result: the walls resisting all attempts to obtain a breach. In the following year it was taken unawares, and delivered up to the king. In 1595, the chateau was taken by stratagem, by a monk—"H. de Sauveaulx of Soissons"—and delivered by him to the Spaniards. Three times it was besieged unsuccessfully by the French king, and finally purchased by him, M. de Sauveaulx having taken refuge in Belgium. Henry IV. then occupied it as a residence for some years.

In 1616, the Marquis of Cœuvre, Captain of Pierrefonds, revolted against the king, Louis XIII., and, after a continued fire of large cannon during two whole days, one of the large towers of the keep fell in, dragging down the adjoining curtain walls; the garrison then capitulated, and the chateau was dismantled by the king's orders. The great towers were mined and blown up; the floors and roofs burnt; and the walls overlooking the town undermined. From that time up to 1858 the chateau became the quarry to the adjoining towns, just as the pyramids of Egypt were to Cairo, and the Coliseum to Rome. In the first revolution it was sold as national property, and afterwards bought, in 1813, by Napoleon I., for 2700 francs (£108.). Taken possession of by the late Emperor, the work of restoration was begun in 1859, and up to the commencement of the late war about 4,000,000 of francs (£160,000.) had been expended; 3,000,000 of which were furnished by the Emperor out of his civil list, the remainder out of the monies devoted to the conservation of Historical Monuments.

These are the chief historical facts connected with the chateau, which I propose to describe as it is supposed to have existed in the fifteenth century, and as it has been restored by M. Viollet-le-Duc. The outworks and fortifications which have been from time to time added round the chateau, chiefly in consequence of the development of artillery, render it somewhat difficult to determine the precise extent of the original works; and I have on this point trusted entirely to the great knowledge and experience of M. Viollet-le-Duc, and have accepted his restoration as correct: my object, this evening, being to describe one of the most considerable restorations of the age rather than enter into an archæological discussion. The chateau was destined from the commencement to serve both as a first-class fortress and as a manorial residence: the first purpose being shown by the height and thickness of the walls, the defensive power of the towers and curtain walls, and the outworks necessitated by the use of artillery; and the second purpose, by the size and arrangement of the keep.

The main block of the chateau is erected on a promontory of land, the plateau or table of which is some eighty feet above the level of the valley. The highest level of this plateau is sixty feet above this, and is situated in front of, and commands the entrance to the chateau. In addition to this, at about 800 feet in front of the entrance gateway, the promontory of land unites with two others and widens into a formidable demilune of attack against which it was most important to provide proper defence. At the time of the choice of the site and erection of the chateau, the artillery used was only of small calibre; and the outworks, therefore, were comparatively slight, and close to the main block.

Reference to the block plan shows the position of the chateau. The higher platform commences to rise at Z; the walls, Y Y, are continued up to the highest point. At X is a small entrance gate; and two others, which still exist, are situated at W and V. The pathway from the former runs round three sides of the chateau to the barbican, U, and gate, T; access to the several points being obtained from the entrance, V. The stables were situated at S.

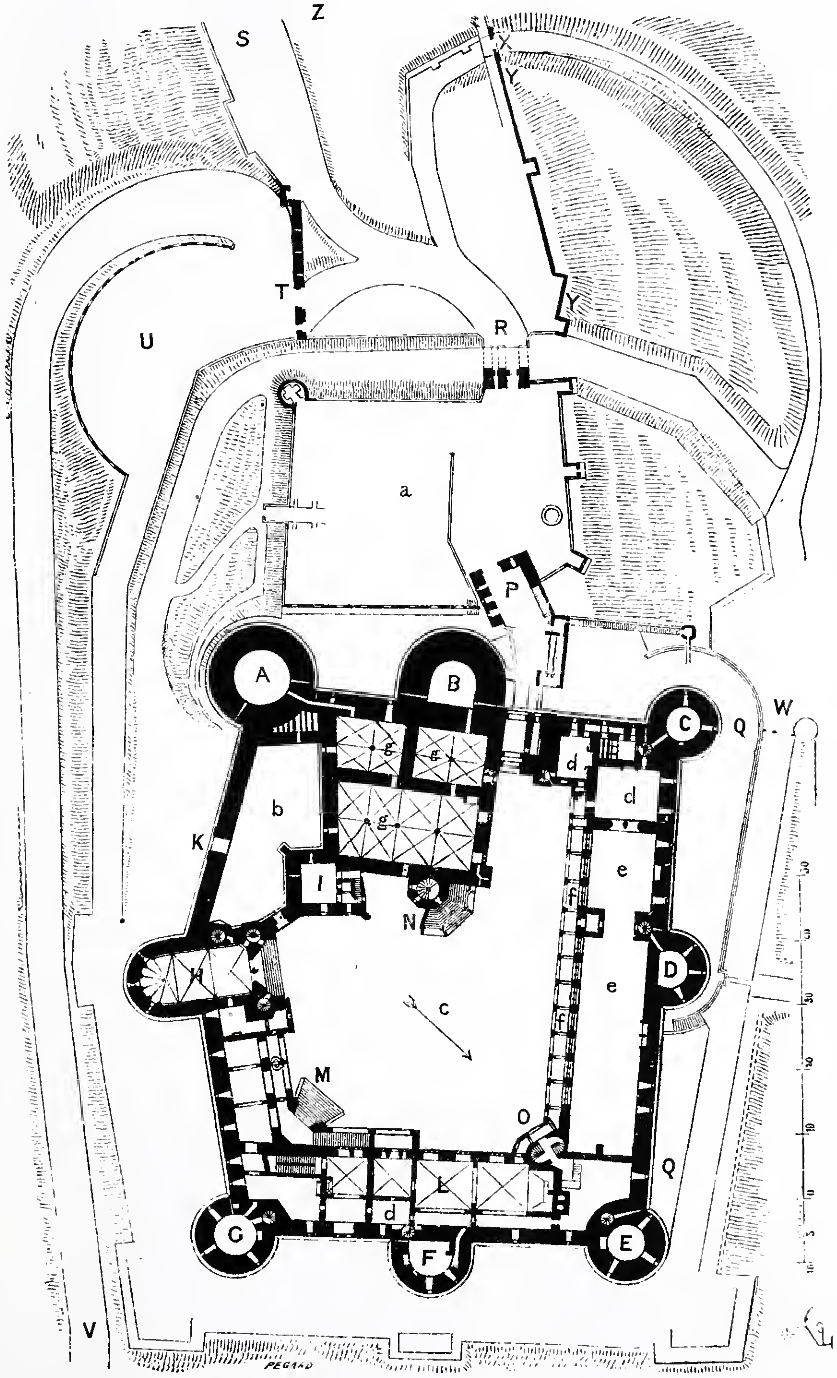
Passing through the gate, T, we reach a drawbridge, R, crossing a moat which cuts off all approach between the higher platform and that on which the chateau is built. Across the drawbridge we reach the esplanade or list, surrounded by barbicans and watch towers pierced with embrasures, and by what is called a "fausse braie." A chatelet, or little castle, P, masks the entrance to the chateau, from which it can be isolated by a wooden floor removable at will. From one of these is a narrow staircase of stone, protected by a wall on one side, which descends to the boulevard, or platform, Q, surrounding the chateau; two small bridges, again, cutting off this communication at will.

The entrance in the chateau itself consists of a large gateway, furnished with a drawbridge and a side door, 19 inches wide, with corridor leading round to just without the first portcullis. Formidable machicolations above defend any attack on this portcullis, so that any of the enemy who might have succeeded in penetrating thus far would be exposed to the stones thrown down from above. Having passed the portcullis, to the left is the guard-chamber, communicating with the vaulted corridor outside the hired soldiers guard rooms. The entrance to the corridor from the court is through the second bay, and its arcades were closed by railings, so that the soldiers in it were thus separate from the service of the court itself. From the corridor entrance was obtained to the vestibule to two other large halls on the ground floor, and to the staircase at the north end of the court: to the description of which features I shall return.

The great towers, eight in number, situated round the building, were designated by the names of great heroes. Thus the towers, A and B, forming part of the keep, were called "Cæsar" and "Charlemagne" respectively; the tower, C, at the corner, "Arthur;" D, "Alexander;" E, "Godefroy de Bouillon;" F, "Joshua;" G, "Hector;" and the tower which forms the apse of the chapel, H, "Judas Maccabæus." Lofty and solid curtain walls unite these towers, all of which are surmounted by machicolations and hoards. In the curtain wall between the Cæsar and Judas Maccabæus towers, was a doorway, K, 38 feet from the ground, closed by a drawbridge, and furnished with a crane by which provisions were raised into the chateau. This doorway opens into a court surrounded by lofty walls and communicating with the large court by a second door, closed by a portcullis and protected by machicolations above. These precautions were taken to guard against surprise in the event of any of the enemy being hidden in the barrels, sacks, boxes, or other packages raised into the chateau.

The keep of the chateau differs from the ordinary form, serving as it did for a residence. It included the two towers of Cæsar and Charlemagne, all the block of building behind them, the square tower, J, and the grand staircase leading to the principal apartments. These latter consisted, on the first floor, of a reception room, 76 ft. long by 36 wide; and five other rooms, three of which are in the towers. The second floor was similarly arranged, the rooms in the towers being vaulted in stone; there being two additional rooms in the roof. On the ground floor were the kitchens and offices, and two ranges of cellars beneath. At the east end of the great court is a flight of steps leading to the rooms occupied by the garrison, extending from the chapel round to the Godefroy de Bouillon tower. The hired troops were placed on the ground floor, and isolated from the main service of the building, and especially from the chief points of defence: the custom being to entrust the main defences only to the immediate vassals of the chieftain, on whom strict reliance could be placed. The kitchens for the garrison troops were situated on the north-east side of the court, at L. An additional garrison of 500 men could be lodged in the guard rooms, on the west side of the court; these rooms being overlooked by the gallery, which forms the first floor of the corridor. The latrines to these guard rooms are situated between the guard room and the Arthur tower. The staircase at the north end of the court was a double one, so arranged that two persons gaining access to it from opposite sides could ascend at the same time without seeing one another.

CHATEAU OF PIERREFONDS.



A. Julius Cæsar tower.
B. Charlemagne ...... do.
C. Arthur .... do.
D. Alexander .... do.
E. Godefroy de Bouillon do.
F. Joshua .... do.
G. Hector .... do.
H. Judas Maccabœus do.
I. Square tower.
K. Entrance door for provisions.
L. Kitchen for the garrison.
M. Staircase to officers of garrison rooms.
N. Grand staircase to Keep.
O. Double staircase.
P. Chatelet.
Q. Boulevard.
R. Drawbridge.
S. Stables.
T. Postern gate.
U. Bastion.
V.W. Entrances to Chatelet.
X. Entrance gate.
Y.Y. External wall.
Z. Foot of high platform.
a. Lists.
b. Stores court.
c. Grand court.
d.d. Guard rooms.
e.e. Soldier's rooms.
f.f. Corridor.
g.g. Kitchen & offices to Keep.

GROUND FLOOR PLAN.

Photo-Lithographed by permission from plan prepared by M. VIOLLET-LE-DUC, Architect.

Photo-Lithogd. for the R.I.B.A. by C.F. Kell, London, W.C.

On the first floor over the guard rooms was the great assembly room,—a magnificent hall, 163 ft. long by 33 wide, preceded by a vestibule, over which was a tribune for musicians. The assembly room served for the great entertainments of the chieftains: it was here that the troops were harangued in time of war, a platform being raised at the end of the hall, in front of the great chimney. A small staircase leading from the centre of the hall communicated with all the external defences, so that any orders given there could be carried at once to any part of the building. This hall served also as the court of justice. The upper portions of the towers were reserved entirely for the defence, and contained the ammunition, in the shape of stones and projectiles of various kinds: the lower portions of four of the towers—viz., the Arthur, Alexander, Godefroy de Bouillon, and Hector towers—contained prisons all vaulted in stone, the only access to which was through apertures in the apex of the vault. The Arthur tower had in addition an *oubliette*.

The Joshua tower contained on each floor the latrines for the garrison. Close to this tower is an additional entrance to the chateau, communicating with the guard room by a small circular staircase; and by this entrance are two (what we may call) speaking tubes in the thickness of the wall, one in communication with a room on the ground floor, the other with one on the first floor; the second one is inclined at an angle of 45°, and is large enough to admit of a man being lowered down through it outside the chateau without opening any of the gateways.

The water supply of the garrison was obtained from a well, 100 ft. deep, situated in the great court; and from a huge rain-water cistern, 80 ft. in length, and about 7 ft. square in section, containing nearly 25,000 gallons. This cistern was placed under the guard room, at the east corner of the court, between the chapel and the Hector tower; and rain was supplied from the roofs, courts and terraces of the whole chateau.

The chapel, situated on the south side of the court, had a fine portal with gallery over, and a large rose window above, affording the principal light to the interior. It was vaulted at the level of the ceiling of the first floor of the keep, and possesses an unusual feature in the tribune over the choir.

In addition to the rooms and hall already mentioned, were those in the roofs and cellars. Of the latter there were two stories, all vaulted in stone, and capable of containing immense quantities of provisions. Besides the principal staircases already mentioned, circular stairs in the thickness of the walls, or in blocks adjoining, afforded access to the towers and curtain walls. They were not formed in continuous flights, but arranged so that it was necessary on each floor to pass through a guard room.

The towers were confided to the care of responsible captains, and so far isolated in the approaches from one to the other, that if one were taken, the others could be defended independently. The whole of the masonry of the chateau was of the finest possible workmanship, the beds of stone being all of equal dimensions (33 centimetres or the French foot, equal to 13 in. English) laid in mortar, with a fine joint. There does not seem to be the slightest trace of any settlement. The lower portion of the walls externally is inclined to form a *talus* or batter; the machicolations and battlements formed the only decoration, with the exception of statues in richly carved niches, one on each of the towers, and representing the hero after whom the tower was named. On the principal front on the curtain wall, between the two great towers of the keep, was a bas-relief representing the Annunciation of the Virgin, sunk in a recess or niche, with canopies over; this bas-relief was fortunately one of the best preserved, as it is one of the most interesting relics of the chateau; and I understand from M. Viollet-le-Duc that similar scriptural bas reliefs were by no means uncommon in the French feudal chateaux.

I now come to the restoration of the chateau, and here I find myself somewhat in a dilemma from the want of record of its original state. I have only been able to obtain one photograph. The view given in M. Viollet-le-Duc's pamphlet is too small to ascertain much with accuracy. In only one or two cases do my drawings indicate the old work, and the autograph drawings were given me in Paris, so that I could not indicate the ancient masonry on them. I can only, therefore, direct your attention to what I described in the earlier portion of my paper, about the attack on the chateau in 1616, and the subsequent destruction by order of Louis XIII.

We are informed that the three towers of Arthur, Alexander and Judas Maccabæus suffered from a tremendous fire, which caused one of the great towers of the keep to fall, dragging with it part of the adjoining curtain walls—that afterwards, in accordance with the orders of Louis XIII, the great towers were mined and blown up, the apartments destroyed, the roofs and floors burnt, and the curtain walls undermined on the side of the town. The photograph shows us that on the north-east side the mining could not have been effected at the base of the towers, because the great gaps in them commence at some twenty feet from the ground; the curtain walls on this side also have only two gaps about 5 ft. wide in them. In the photograph of the north-west side of the restored chateau it will be seen that a portion of the central tower (Alexander) has had its batter restored, that the Arthur tower has been almost entirely rebuilt from about 30 ft. above ground, and all the upper portion of the curtain walls adjoining. That a gap only of the wall between the Alexander and Godefrey de Bouillon towers was filled up, and a narrow slip in the latter tower. On the principal front or entrance side a great portion of the two larger towers of the keep were blown up, and the curtain walls between them partially destroyed. The small square tower at the back was almost entirely preserved.

On the chapel side of the chateau the curtain walls have been largely restored; the old stonework, however, existing in the upper part of this wall shows us that the restoration consisted chiefly of face-work. The walls of the chapel existed up to the machicolations and inside, the springing of all the vaulting was preserved. M. Viollet-le-Duc's woodcut, taken from the east, shows us that the Cæsar tower was razed to the level of the interior courtyard, but that the keep still retained a portion of its walls to their full height, including the chimney stacks.

In addition to the information thus obtained from drawings and photographs, M. Viollet-le-Duc, in his pamphlet, remarks of the building before its restoration: 1st. That the whole of the exterior walls remained standing, and consequently the height of all the floors was determinable. 2nd. That the portico on the inside of the court was given by the thickness of the walls, and by fragments found in the excavations. 3rd. The level of the mezzanine gallery was given by the staircase in the Alexander tower, which was carried up to that level only. 4th. The position of the staircase L was given by its plan being preserved. 5th. All the chimney-pieces and flues could be traced in the walls. 6th. The arrangement of the grand chambers and approaches, and all the latrines were preserved. 7th. That fragments of the mullions, cornices, and other decorative details were found in the excavations. 8th. The slope of all the roofs was given by the weather-courses on the Godefroy de Bouillon tower; in addition to these remains, the springing of all the vaulted roofs existed, and on the exterior the greater portion of the machicolations with the toothing of the stone hoards and upper parapets.

It will be seen, therefore, that the main difficulty with which M. Viollet-le-Duc had to contend was the want of sufficient data for the immediate outworks, and for the whole of the interior, and here his great archæological knowledge stood him in good part. I have not deemed it advisable or necessary to enter into the strategical reason which have led him to the precise arrangements adopted, though they are given at length in his pamphlet. I venture, however, to refer in terms of the highest praise to the extremely picturesque disposition of the approaches to the main gate, the architecture in the interior of the courtyard, and also the whole of the decoration which he has designed for the chief apartments. The restoration of the exterior walls and towers, comparatively easy as far as the repetition of existing forms was concerned, must have called for very great practical knowledge in the design and erection of scaffolds, and I regret very much that I was unable to visit the chateau in the earlier years of its restoration, in order to have seen the scaffolding, especially as on these points M. Viollet-le-Duc is *facile princeps* in France, having almost, I may say, created a revolution in the principles of their construction.

In consequence of their immense thickness, and of the excellent quality of their masonry, the walls had all retained their vertical positions, and, excepting for the interior vaulting and small internal walls of slight importance, no underpinning was required in the restoration. The breaches and gaps were filled in, and the masonry in the upper part of the walls was executed in the ordinary way; that is to say, for the exterior walls, rails were laid round the whole of the chateau, on which the materials were drawn to their respective position, and raised by means of an immense steam crane; the thickness of the walls otherwise allowing the materials for cross walls to be rolled along on their summits. For the interior walls the scaffolding was continuous, the stones being placed in position by travellers.

The stone details for the windows, cornices and other decorative features were built in block, and carved or moulded in their respective positions; this applies only to those parts which were built with the soft limestone of France; whenever a harder stone was employed, it was carved or moulded first. About 18,000 cubic metres of stone were employed in the restoration, all obtained from the neighbourhood of Pierrefonds. The chief varieties being Laversine cronï Villiers, liais de Senlis (all hard stones), from Pierrefonds itself the soft stone (Pierre tenche), and from Hautefeuille and Senlis the banc royal; these several varieties coming from the same quarries as those in the old building.

The floors of all the large rooms are carried on oak girders, the material being obtained from Villers-Cotteret, and the forests of Laon and Coucy, the oak of the forest of Pierrefonds being valueless for trusses or girders. These oak girders are halved and trussed; and the ends rest on stone corbels, the design of which varies in the several rooms. On these girders are laid joists 6 in. by 8 in. deep, with a space of from 7 to 8 in. between; on the top of these the battens are laid with a bed of plaster of Paris on them, from 2 to 3 inches thick, the ceiling beneath being formed between the joists. The flooring joists are laid on the plaster of Paris, being kept in position by the same material, and the flooring boards are of $\frac{3}{4}$-inch oak. The trusses of the roof are all in iron, as well as the purlins, rafters, and laths or battens to hold the slates. The latter are suspended in an ingenious manner on the iron laths (which serve as slate battens) by small clips of copper, so that any slate can be taken out and replaced, if necessary, without disturbing the others. The slates, which are of a deep violet colour, come from Furnay in the Ardennes. These constitute the chief constructive points; I have yet to direct your attention to those portions of the interior, viz., the court-yard, staircases and rooms, the design of which may be said to be more or less original, though based by M. Viollet-le-Duc on the architectural fragments found in those excavations.

Commencing as we enter the courtyard, on the left is the exterior of the great assembly room, the arcade below it and gallery above forming corridors outside the guard rooms. This corridor externally is divided into bays, 13 ft. wide; on the ground floor is a three-centred arcade, carried on stunted columns, and the mezzanine floor is lit by three trefoiled headed windows under a segmental arch, a balustrade crowning the whole. The interior of this corridor is vaulted with segmental barrel vaults in stone panelled, each vault abutting on its neighbour. The transverse wall between each bay has on the ground floor a segmental arch, with huge keystone, and on the first, or mezzanine floor, a trefoiled headed arch, carried on corbels. The great windows of the assembly room have solid mullions and light transoms above the balustrade to every alternate bay below, and dormer windows similarly treated. Continuing round on the north side is the belfry, an extremely picturesque feature; below it is the great window lighting the vestibule to the apartments of the garrison officers. The jambs of this window descend to the ground floor in the form of buttresses, which are corbelled out and carried on massive columns, with carved capitals, a lofty arch being thrown across between. This marks the chief entrance to the guard rooms of the back entrance to the chateau. Beyond this feature is the great flight of steps leading to the entrance of the offices of the garrison's rooms; the stairs rising to the first floor being strongly accentuated in the external architecture.

On the east side of the courtyard is the chapel, which is perhaps one of the happiest features. The lower portion is an original treatment of the flamboyant porch; the rose window above is perhaps somewhat decadent in style, but was, I believe, based on the original feature; the gable and corner buttresses are well proportioned and fine features. The staircase leading to the principal apartments in the keep forms one of the more remarkable features in the court. It is preceded by a grand porch with three archways, and an external flight of steps; internally the staircase is circular, externally octagonal, the windows lighting it rising with the steps.

The decoration of the interior is not yet completed in all the rooms; with the exception of the great assembly room, and a vaulted chamber in the Cæsar tower, its principle is the same throughout; a dado in oak, carved and panelled five feet high, runs round the principal apartments, above this the wall is stencilled with various devices, and a deep frieze is carried round the upper part of the walls, with figure or ornamental decorations; the chimney pieces are all in stone, carved and richly painted and gilt. The oak girders are carried on stone corbels, carved and painted. The woodwork on the ceiling is painted of a dark ground colour, relieved by light colour ornament, the ceiling between the joists having dark ornaments on light ground. The decoration varies in every room, and has all been designed expressly by M. Viollet-le-Duc; the colouring is quiet and extremely harmonious in tone, and is perhaps the best evidence of the wide range of his talents. The room in the Arthur tower has an octagonal vaulting, the chimney piece being decorated with a representation of King Arthur and the Knights of the round table. The great assembly room has been turned to account as a museum of arms; these were, I am sorry to say, removed to Paris during the late war, and have not yet been restored to their places; the hall is surrounded with cases to hold the collection, which is, I believe, of great value. The roof consists of a pointed barrel vault in wood, painted with various devices, the boarding being fixed to the iron trusses of the roof. The chimney piece in this hall is the finest in the chateau. It is double, having two grates in it, with tiles at the back. Above are placed, in niches and on pedestals, the nine heroines of antiquity, distinguished by heraldic devices and surmounted by a crenelated cornice, with miniature turrets and battlements.

In conclusion, I have only to add that, although the restoration was necessarily stopped during the late war, I have every reason to believe that it will be continued and completed; though at present, owing to the lack of funds, there are but a few artists at work. The whole work reflects the greatest credit on M. Viollet-le-Duc, who has devoted to it an immense portion of his time; and it places on record for future generations one of the most interesting features of the feudal period of the middle ages. I cannot let this occasion pass by without expressing my warm thanks to M. Viollet-le-Duc for the facilities of study which he gave me, and more especially for the very fine collection of drawings and general information which he placed at my disposition, in order that I might be able to illustrate my paper, and thus render the subject more worthy of the consideration of the members of this Institute. I have also to express my obligations to Mr. G. H. West for the original study for the interior of the court by M. Viollet-le-Duc, which he has been kind enough to lend me.

At the invitation of the CHAIRMAN, the following communication was then read from Mr. G. H. WEST, Associate :—

"The Chateau of Pierrefonds is peculiarly interesting from its being, perhaps, the most perfect example we possess of an attempt to unite a strong fortress with a commodious palace. Coucy was above all a fortress, Blois, Bury and Chambord above all palaces, but Pierrefonds attempts to be both; and if any sacrifice was made, the palace was sacrificed to the castle. To compare great things with small, it holds much the same place between Coucy and Chambord as Carnarvon does between Corfe and Hurstmonceux.

"Coucy was built at the time when the feudal system had lost none of its force, when the seigneur was regarded more as the protector than as the oppressor of his vassals; when the royal power was weak, and every great seigneur was in his domains a far more important personage than his sovereign; when the castle and the village formed one fortress, as at Conway, and the inhabitants of the latter became the garrison of the castle in time of war. Treachery being little apprehended, was scarcely provided against, and the soldiers lived almost in common with their lord. But when Pierrefonds was built, the Royal power, though weak at that particular time, had grown immensely at the expense of the feudal lords, and was looked up to and respected as much as they were hated and feared. While the inhabitants of Coucy could read with pride the motto on the castle gate—

'Roy ne suis
Ni Prince aussi,
Mais je suis le Sire de Coucy,'

—and feel the safer for its boldness, those of Pierrefonds could only look with dread on the abode of the rebellious noble whose schemes, had they not been cut short by his rival's dagger, would have devastated all their land. In his plans Pierrefonds, together with Coucy, Villers Cotteret, La Forté, Milon, etc., were intended to fortify the whole district of Le Vallois against the King. At the same time Pierrefonds was to be his own chief palace, and the key to the whole district. We therefore find throughout the whole building the two services—civil and military—kept completely distinct, but with constant and ready communication from every part of each to every part of the other. But as castles were no longer defended by trustworthy vassals, but by bands of those worthless mercenaries who, for the next two centuries, became the curse of Europe, every precaution had to be taken against treachery, and the whole garrison had to be kept under complete control and constant supervision. I will not enter into detail, as it would be impossible to do so to any purpose without a large scale plan, but will mention one or two points. After having gone all round the outside of the castle, through the yard and the double entrance gates, one finds one's self in front of the portcullis, with a large machicoulis over one's head, through which pitch, stones and other pleasantries might be poured upon one. To reach the castle yard, either the portcullis must be raised or one must turn sharp to the left, and so enter the guard-room, the door of which opens between the portcullis and the gates. Thence one can either pass into the castle yard, or into the mercenaries' hall, which occupied the whole ground floor of the east wing. But the mercenaries could not get from their hall into the yard, because of an arcaded portico running its whole length, the arches of which were barred, so that, while they could walk up and down and get air, they could not get into the yard without coming back through the guard-room. This portico only occupied half the height of the mercenaries' hall, the upper part opening on to the hall and forming a gallery to it, approachable only from the donjon and the grand' salle, which is above the mercenaries' hall. Thus, while they could not get out, they were completely commanded, The seigneur had also a small private staircase, going down from the *grande salle* to the mercenaries.

and up to the defences. The mercenaries had also a staircase leading straight to the defences, and not communicating with any other part of the castle; or, from the guard-room one might go up a small stairs to the ante-room of the *grande salle*, and passing through that to the *grande salle* itself (or justice room), out of which opened the torture room. Thence the condemned were led into the south-western angle tower, the two bottom stairs of which were dungeons approachable only through the eye of the vault, the bottom one possessing oubliettes in the shape of a deep dry well in the centre. That these were dungeons is shown by their having privies.

"One more strategic point may be mentioned. In the north wall is a sallyport on the level of the ditch. From just outside this door a square speaking tube, measuring about 2 ft. by 1 ft. 6, so that a man could slide down it, communicated with two guard rooms on the ground and first floors respectively. This door had two locks, so both guards had to unite to open it; and it was impossible to warn one without the other. Should any one by chance get inside the door, they would have to know their way well to reach the castle yard; for, of the three perfectly dark passages open to them, the one on the right is a long *cul de sac*, that in front ends abruptly over the immense rain water cisterns of the castle, and the other, after going half round the castle, leads to a small concealed stair into the *inner*, or donjon yard, and there lands you under a *machicoulis*, in front of a door with double gates and portcullis.

"One of the most remarkable things in the castle is the chapel. The western half of it is all in one storey, the whole height of the tower, while the eastern half is in two storeys; so that from the west door you see an arch thrown across the commencement of the apse at half its height, and two altars, one above the other. In case of siege the soldiers could collect from the ramparts and attend mass without neglecting their duty. There are several different galleries, or rather 'loges,' in the chapel, the seigneur's being turned slightly forward out of the regular line of wall to give him a better view of the altar. Each of these galleries have separate approaches.

"There are many other points worth referring to, but it would be hard to make them intelligible without plans. Among the modern works, the roofs may be noticed. They are formed of iron frames screwed together, and stiffened by the iron lathes on which the slates are hung, so that no trusses are necessary: the slates are hung on hooks. Each slate thus gets four hooks to hold it,—one of its own at the bottom, one on each side of the slates next above it, and one on it at top in the middle of the row above that. If a slate needs removing, the end of the hook is turned down, it is slipped out, and another substituted. This system is very common now in France, and is far preferable to nailing; but I doubt whether it would do for our large English slates.

"In conclusion, I must beg to apologise for these very brief and imperfect notes, and to express my regret that I was unable to attend this meeting. I only wish I could have done so, but it was quite impossible. I have also to thank my friend Mr. Spiers for kindly sending me a proof of his interesting Paper on this most attractive subject. As he has not touched upon this strategic view of the subject, I have ventured to notice these one or two points.

"Last time I was at Pierrefonds, M. Wyganowski, the inspector, told me that whereas they formerly never got less than 30,000 francs a month, they considered themselves very lucky in having obtained a promise of that amount annually. I know that M. Viollet-le-Duc has for years been pushing on the work as fast as possible, because he did not think such an expenditure could last for long even if the Empire did. This will account for the suppression of the extra storey in the belfry (shown on the sketch), and several other deviations from the original design."

Mr. B. BUCKNALL said,—The Chateau de Pierrefonds is not only highly interesting as a restoration, showing what a great castle of the Middle Ages was at a period when, before the employment of cannon as a powerful arm, the art of defence had reached its most scientific development; it is not only interesting for the consummate skill and ingenuity of its arrangements, the science of its construction, and the grandeur of its architecture;—there is another point of view, that must render it doubly interesting to us architects and students of architecture, which is, that in his admirable restoration, M. Viollet-le-Duc shows us how the architect of the Middle Ages, the skilful and intelligent builder of the original castle, would have proceeded, had he possessed the materials, the appliances, the scientific knowledge, and the facilities for study that the nineteenth century affords, in addition to those that were possessed by the fourteenth. He shows us, in his cleverly constructed roofs, floors and bridges, the scientific employment that the mediæval architect would have made of wrought iron if he had had our command of that material; in the original design and grand art of his sculptural and painted decorations, the intelligent use which the ancient artist would have made of the innumerable models furnished by our museums, &c.; how by his reasoning and the application of principles he would have found, out of the mass of materials thus supplied by the nineteenth century, a new and original architecture, the outgrowth of the past and the expression of the present,—an architecture whose vigorous forms and noble art becomingly interpret the material and intellectual power of our age. While faithful in all the essential points of a restoration, and without for one instant departing from the spirit of the old work, M. Viollet-le-Duc has, wherever it was possible, perfected the means of construction, and given a character truly original and truly his own to the architectural adornments. It is not from personal admiration of the man that I speak in such praise of his works, but from a careful and critical examination of them,—because I find that they possess all the qualities that constitute a true and original architecture; they are planned so as simply but perfectly to meet their requirements; their construction is simple, sound, and scientific; intention reigns throughout, reason has dictated every form; the lines are graceful and vigorous, the ornamentation pure and artistic; there is order, harmony and unity. What more is needed? It does not take two eyes for any one who is acquainted with the difficulties of our art to see the perfection of his work: every unprejudiced and candid mind will feel that he is in the presence of a great master. Not only Pierrefonds, but all his numerous works, as well of restoration as of new construction, merit, I think, our most interested and careful study. You will look in vain for the types of Viollet-le-Duc's architecture among the schools of the past: it is a school of its own; that, whether we follow or not, we must study, if we would not be left behind, and which we shall find doubly instructive, because it is contemporary.

After some remarks from Mr. W. Burges, who observed that although he could not altogether agree with the last speaker in his estimate of M. Viollet-le-Duc's works in general, he willingly admitted his skill as an archæologist, Professor Kerr proposed a vote of thanks to Mr. Spiers for his Paper, and to the gentlemen who had supplemented it by their interesting communications.

Mr. W. H. WHITE, Fellow,—I rise to second the vote of thanks which has been proposed to Mr. Spiers for this most interesting paper. I am sorry I have never seen this chateau, and that I am not in a position to pass a judgment upon it, as one might be entitled to do who had studied it on the spot, but as far as the drawings show, it strikes me as being a very successful restoration. It is rather difficult to see where the old work left off, and where the new began, and as I understand the character of the new work was dictated very much by that of the old work, excepting in what I think was an important part, viz., the structure of the fabric of the roofs, of which we have had a description. The fabric of the floors, I suppose, would be much what it was in the old days; but certainly the architect has diverged from all that has been accepted as restoration of an old work in a building of that description by the construction of light iron roofs instead of what would be used of old, and revived now as fire-proof construction, viz., vaulted roofs. I cannot help thinking that, for a building of this class, it would have been better if vaulted roofs had been carried out in lieu of iron ones in such a vastly interesting building as this is. I think the outline—the sky line—and the upper treatment, as compared with the massiveness of the lower part, is very fine indeed. I beg cordially to second the vote of thanks.

Mr. Bucknall,—The iron roofs do not replace vaulting in stone. It is only the timber work which they replace. I would particularly call attention to the admirable system adopted for replacing broken slates.

Mr. C. F. Hayward, Fellow,—Leaving personal questions aside, I would ask whether the word "restoration" is not one which it is desirable should be explained. Looking at the severe remarks which our President made in his opening address on restorations in this country, it is important for us when talking about such matters to make a distinction between restoration and re-building in such a work as that now before us, in order that we may understand, at least amongst ourselves, what "restoration" really means, for I think we sometimes make an indiscriminate use of that word. If this work, which has been so ably described to us, is a restoration, it is scarcely my idea of the meaning of the word, which I take to be the carrying out of the old work as far as it can be carried out, and as far as there is occasion for it; not re-designing it, nor adding a large quantity of new and original work, and especially not deliberately altering the original construction by carrying out roofs in iron where they were formerly of wood, nor (as has been suggested just now) vaulting over spaces where there was no vaulting before. The object of restoring these ancient buildings (at least in most cases) is simply to show what they were originally, not what they might have been if the architect had lived in the nineteenth century. With respect to the iron roofs in this structure, we find they are put together in such a way as we should adopt in our ordinary practice, and the same may be said of the manner of fixing the slates. To apply these modern ideas to the restoration of a work of this kind I think is questionable. I state my opinion for this reason. I look forward to the possibility that at some remote period hereafter, even in England, we may have a Government so interested in our art that they may see their way to assist to preserve, or do something to prevent the decay of various ancient buildings which, to us at least, are more interesting than similar buildings in France. Take, for instance, those fine old buildings Hedingham Castle and Rochester Castle. Those are fine old structures of similar character and date, containing beautiful stone work as perfect now in many respects as it was in the days in which it was put together; but they have been ruined in various parts by the chances of war rather than by time, except in the floorings and other wood work, which has of course decayed. Supposing a large sum of money was proposed to be expended in the restoration of those buildings, after the manner in which it has been done in the case of this old chateau. I must confess that I could not approve such an outlay, for though I particularly desire that our ancient buildings should be well looked after, I should deprecate the spending of a penny upon them if the result were to be like that which we have now before us. I think this is important just at this time, because I should not like it to go forth, after the very strong and justly severe language which our President addressed to us about the destruction caused by restoration in our own country already, that this Institute endorses the principle involved in the particular kind of restoration which has been described to-night, however magnificent the work itself might be.

Mr. Blashill,—With reference to the upright condition in which the walls of this building have remained, I think that circumstance, together with the photographs, shows very conclusively that no gunpowder was employed upon them. Every one who has observed the effects of gunpowder when employed for this purpose, as in the remains of Corfe Castle, will see that the effects of gunpowder would be very different from those shown in the photographs; and I apprehend that the way in which the towers were rendered useless for defence was by beginning at the top, and cutting the wall for a width of three or four yards down, to a sufficient depth to render the towers untenable against the means of attack then in use. Whether gunpowder was used in destroying other parts of the walls is a matter of question. With reference to what has fallen from Mr. Hayward, I would suggest that a wooden roof over this chateau would have been as much open to objection as an iron one, because it would not have been a copy of the original, and I think that, looking to the danger of fire, it justified the architect in avoiding a wooden roof.

THE CHAIRMAN.—We have now reached the time for closing our proceedings, and it remains for us to express our acknowledgments to our friend Mr. Spiers for his paper, and to Mr. West and Mr. Bucknall for their supplementary communications. I quite agree with what Mr. Hayward pointed out as to the difference between restoration and rebuilding. Restoration is what we are bound to undertake with fidelity to the original; whereas in rebuilding we may take the licence of our own views, rather than with reference to what existed before. At all events, I am quite sure we shall all be agreed in the vote of thanks which has been proposed to Mr. Spiers and the other gentlemen for their communications.

The vote was unanimously agreed to.

MR. SPIERS, acknowledged the compliment paid him, and having drawn attention to some details in the drawings, said: with regard to these restorations having been carried out at the expense of the civil list, Mr. Hayward has taken up a point which I think is very important: throughout France every building of historic value is registered, and a description of it is deposited in the archives of the country; these descriptions are generally quoted from in the guide books, and as they are made by distinguished architects, and after careful examination, they are of great value to the traveller. These records show that all the ancient buildings of any importance are looked after by the Government, and that when opportunity occurs, they will, as far as possible, be placed out of danger of decay. Throughout France this is done; and, though I think the restoration in some cases is too comprehensive, still it is gratifying to find that the authorities will not allow these interesting structures to be entirely destroyed. With regard to gunpowder not having been used in the attempted destruction of the walls, I am quite of Mr. Blashill's opinion. We know how extraordinary the power of gunpowder is in lifting up a wall. I remember after the siege of Paris, in 1871, I examined the walls of the Hotel de Ville, which was fired and blown up by the Communists, and found that, inasmuch in some places walls sixty or seventy feet high, and two or three feet thick, were thrown out of their vertical positions. This could not have been done in the case of this chateau, because the whole of the walls retain their upright position.

The discussion having then been brought to a close, the meeting adjourned.

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 12th of January, 1874, Sir G. G. Scott, President, in the Chair, the following Paper was read:—

SOME OF THE SANITARY ASPECTS OF HOUSE CONSTRUCTION.

By Captain Douglas Galton, C.B., F.R.S., Director of Her Majesty's Public Works and Buildings.

The architect is an artist, in that he has to beautify the structures which he erects; he is an engineer, in that he has to consider the strength and qualities of the materials to be used, and to apply those materials according to definite rules; he is a sanitarian, in that, in the construction of domestic buildings, he has to consider the conditions affecting health—and the conditions affecting health are as much the subject of accurate rules as those which regulate the strength or beauty of a structure.

My remarks on this occasion will be limited to that portion of the architect's functions which relate to what may be termed healthy construction. Most of the facts and conditions are well known to the members of this Institute, but it seems advisable at the present time, when Parliament is directing its attention to sanitary measures of which the construction of healthy dwellings forms an important branch, to lay the subject before your Institute in a connected form, with the object of showing the considerations which regulate the construction of human dwellings in reference to the health of the occupants, rather than to their architectural features. Moreover, a large number of houses are built by speculative builders without reference to architects, and, in these, considerations of health are little thought of.

The conditions necessary to secure the health of the inmates of a building should be present to the mind of the architect in the formation of his original design, as much as the strength and qualities of the materials with which he has to build; and upon these conditions should be engrafted those of comfort, convenience, and beauty. Palladio somewhere says that architecture, being grounded upon rules taken from the imitation of nature, admits of nothing that is contrary or foreign to that order which nature has prescribed to all things. This remark is peculiarly applicable to healthy house construction; for nature prescribes that stagnation breeds putrefaction, and that health depends on the absence of stagnation; in other words, air must be kept in motion, and water must not stagnate.

The requirements for health may be classed generally under the heads of:—

1.—The purity and cleanliness of air.
2.—An equable temperature.
3.—Sufficiency of daylight.
4.—Purity of water.

The latter consideration I will leave untouched on the present occasion, as it depends rather upon considerations outside the house, than upon the constructional arrangements.

Sufficiency of light is a material element of health; sunshine acts as a purifier of the air. In uninhabited rooms when the shutters are closed there will be found a close musty smell. This smell will be removed by the admission of sunshine, and thus daylight and sunshine assist in obtaining purity of air, which is the cardinal point in the construction of a healthy house.

The other two conditions fall naturally under the four chief heads of first, *The site*, which should be dry, and not malarious; secondly, *The general arrangements* of the building, which should prevent stagnation of the air, and provide for the speedy removal of refuse; thirdly, *The materials*, which should insure dryness of foundations, walls, and roof, and be retentive of warmth, so as to prevent rapid changes of temperature; and fourthly, *The ventilation*, which should carry off the emanations constantly given off in respiration, etc. At first sight these propositions appear so obvious as to render it unnecessary to enforce them by an essay. It may be urged for instance that no person who has studied the subject would build a house in a wet situation, where the purity of the air would be injured by moisture; that no person would select materials which would permit the wet to penetrate the walls; that the ventilation would be contrived so as effectually to prevent the smell of cooking from pervading the house. Yet how numerous are the houses in which every one of these obvious rules are transgressed!

A further condition of health is the maintenance of *perfect cleanliness* within the dwelling. This, no doubt, properly belongs to the occupiers of the house, but the architect is concerned in it to this extent—that cleanliness is promoted by abundance of light, and by the absence of dark corners. A dark house is an unhealthy house, an ill-aired house, and a dirty house.

I.—SITE.

It having been assumed as an axiom that no stagnant water should be allowed in the vicinity of any building site, either above or below the soil, it follows that surface drainage should be provided round all building sites. Houses should never be placed against the side or foot of a slope. Such a position is a fertile cause of fever, and is especially to be avoided when a bed of clay crops out near the foot of the slope. Houses should not be built on or near accumulations of refuse, as so frequently happens in the case of houses built in and near London.

In connection with these considerations houses may be classed under four heads or divisions:—

(*a.*) Large houses in their own grounds.
(*b.*) Houses of a similar class in towns, where the influence of elevation, position, and external ventilation cannot be depended on.
(*c.*) Cottages in the open country.
(*d.*) Artizans dwellings in towns.

The first division, viz., large houses in their own grounds in the country, may depend for pure air upon their elevation, position, and exposure; and the owner who has control of the land around can take all necessary measures to secure purity of the surrounding air. In selecting sites for barracks, the general suitableness of the place is certified to by the commanding officer of the district; the capabilities for water supply and drainage, by the engineer officer; and the healthiness of the locality and exposure, by the medical officers. In civil life it is generally the architect who decides all these questions.

In the case of the other three classes enumerated above, viz., houses in towns and cottages in the country, it is difficult for any member of a community to separate his interests in the matter of health from that of his neighbours. The air may be contaminated by the action of persons over whom the owner of a house can have no control. The health of the community is thus dependent upon a proper supervision being maintained over the proceedings of the several members constituting it. This control, to be effective, must be vested, to a great extent, in persons professing architectural knowledge; and it is almost a certainty that before long Parliament will have recognized the necessity of placing upon qualified surveyors the duty of seeing that sanitary requirements, including the internal arrangements, the use of proper materials, and the drainage, are adequately provided in all new houses and cottages over the whole country. There is at the present time a supervision established over certain matters of construction, in the case of houses in some of our principal towns, but in very few cases are these requirements connected with the health of the occupants.

II.—General Arrangements.

I have already shown that an abundance of light and direct sunshine are necessary for maintaining purity in the air. In hot weather the inner temperature of the house should not be raised by the heat of the sun passing through the roof or walls. The purity of the air in hot weather is generally maintained by open windows and open doors; but to insure this it is necessary to design the house so that a free current of air may be passed through all parts of it. Hence back to back dwellings are not advisable. In towns there should be at the back of every house a clear air space from the level of the lowest part of the basement along the whole width of the house, between it and the next building, and the doors and windows should be so arranged that when they are all opened they allow a current to pass through the rooms, and do not leave any portion of the air in a stagnant condition. In cold weather, on the other hand, the air of the house is required to be maintained at a higher temperature than the outside air. The heat generated in the house should not pass away through the roof and walls. Arrangements for maintaining purity of air are chiefly required for cold or damp seasons. The upward movement of air warmer than that of the outside air, will draw up air from the basement, consequently the purity of the air of a house in cold weather will depend on the purity of the air in the basement, unless the basement is entirely cut off by solid arching from the house. The air of the basement, if it be below the level of the ground, will be rendered impure by fumes from the kitchen (if in the basement) and the cellars, and it will be derived partly from the adjacent soil. This air is generally impure.

The deleterious character of the air in the soil is chiefly due to the large proportion of carbonic acid which it contains. Dr. Pettenkofer's experiments show that at a few feet below the surface, the proportion of carbonic acid in the air is greater than that in the worst ventilated dwellings, and that the proportion of carbonic acid in the air taken from the soil is twice as large as that found in water collected from the same place. He showed that the quantity of carbonic acid at a depth of fifteen feet from the surface was greater than that found at five feet from the surface, during the whole year, except during June and July, when the proportion of carbonic acid was greatest at the higher level.

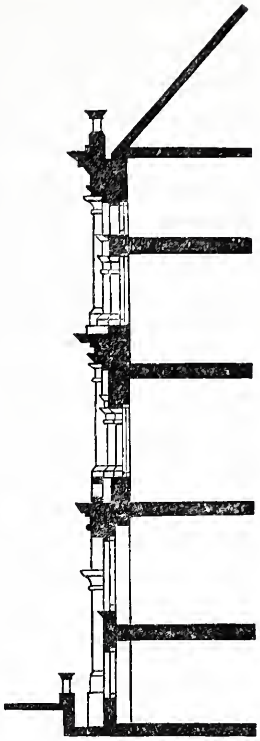
But there are other causes of impurity in the air which permeates the subsoil. In inhabited districts the organic matter left to putrefy in or on the soil injuriously affects both the air and water in the soil. In towns the emanation from the gas pipes are a serious source of impurity to the air in the soil. So also is the leakage from sewers; from both these causes the air in the subsoil is eminently polluted. Consequently the purity of the air in the basement will depend partly upon the arrangements in the basement itself, and partly upon the purity of the air in the subsoil under and around the house, unless the basement has been entirely cut off from the surrounding ground by a sufficiently thick and continuous bed of concrete or a layer of asphalte laid over the whole surface covered by the house, and by sufficient areas carried below the level of the basement, cutting it off by an open-air space from the adjacent soil.

The floor of the basement, whether it be of wood, of stone, or of tile, should be from one foot to eighteen inches above the level of the surface of the area or ground surrounding it, and it should have a space under it for the circulation of air, and a damp course, either of asphalte, slate, glazed pottery, or other impervious material, should be laid below the level of the floor. By such means only can the floor of the basement be maintained in a dry condition.

As regards drainage, water will always be found to be the most convenient carrier of fœcal refuse. The dry earth system is convenient in some cases, and in cottages in the country districts water closets would be expensive and inapplicable. All drainage arrangements, as a rule, should be against the outside walls of the house; but where it is absolutely necessary to carry a drain under a house, special arrangements should be made for access to and inspection of the drain pipes, which should be watertight in themselves, and they should not be buried. No cesspit should be allowed in or near any house. In large country houses it is possible to utilize the sewage for agricultural or horticultural purposes. In cottages in the country sinks and wash-houses should be outside the dwelling house wall; the privies, or dry earth closets, should be in out-houses separated by an air space from the house. If a cesspit cannot be dispensed with it should be at least twenty or thirty feet from the house, it should be made watertight, be ventilated, and be small to compel frequent emptying. In towns cesspits should never be permitted. If sewerage is not provided the midden refuse should be removed daily. Ashpits and receptacles for stable manure should never be below the surface of the ground. They should be paved and drained, and they should be small to compel frequent removal of their contents. Between any cesspit or any main sewer and the house, there should be a trap in the drain to cut off communication between the house and the main sewer or cesspit, and there should be an air pipe carried up from the drain between the trap and the house to above the roof level to ventilate the drain. There should also be a ventilation from the cesspit, or in the main sewer, so as to render their ventilation independent of that in the house drain. Further, all down pipes of house drains should be carried up to above the roof and left open at the top, and be carried down into a trap at the bottom. Waste pipes from cisterns or sinks should not be carried into a down pipe connected with the drain, but empty into a trapped grating so as to leave an air space between the waste pipe and the trap: and so prevent the possibility of the waste pipe acting as a conductor of sewer gas into the house. Water cisterns always give off moisture; it is therefore unadvisable to place them in or near the occupied part of a house; but all cisterns and water pipes should be so placed as to render their freezing impossible under any ordinary circumstances, because where the safeguards against sewer gases mainly depend upon the security of water traps, any interruption to the flow of water is a source of danger. Water pipes laid under ground in the open air will not be safe from freezing at a less depth than from twenty to thirty inches.

Plans for houses must necessarily vary with the wants of individuals; it is, therefore, only possible to lay down some few general principles which should be observed in the design. Amongst these, perhaps the most important for living rooms are those concerning windows, in the arrangement of which sanitary principles are frequently sacrificed to the design of the façade of a building. The model selected is frequently that of an Italian house; but in Italy windows are few and deeply recessed to keep out the heat and the brilliancy of the sun, whilst here the clouded sky makes an abundance of light necessary. For sanitary purposes the windows should be carried as near the ceiling as possible, and the lower the room the greater the necessity to observe this rule in order to freshen the air. Moreover, it is an element of cheerfulness in a room for the sills of the windows to be brought down near to the floor.

The accompanying diagram, illustrative of a recently erected building, will serve to show how the conditions of design in Italian Architecture may interfere with this important sanitary requirement.



The proportion of window surface to the cubic contents of the room is of great importance, but it must to some extent depend on the aspect; instances could be pointed out of houses where architects have given to rooms of the same cubic contents, of the same form, the same aspect, and to be used for similar purposes, a window area twice as much in one room as in another to suit the façade.

In this climate adequate light will not be secured with less than one square foot of window surface to about 100 or 125 cubic feet of the contents of the room. This should be a minimum allowance, and assumes that the windows in all cases are of clear glass, but greater cheerfulness will be secured by more light. The effect of different qualities of glass on the diminution of light is shown by the following results of recent experiments:

Polished British plate glass, $\frac{1}{4}$ in. thick intercepted	13	per cent. of the light.
36 oz. sheet glass . . .	22	,,
Cast plate ditto, $\frac{1}{4}$ in. thick . .	30	,,
Rolled ditto, 4 corrugations in an inch .	53	,,

The most convenient form of window for ventilation in this country is the sash window opening top and bottom. This mode of construction enables a current to be maintained, fresh air passing in below, whilst the vitiated air of the room passes out at the top. It is an absolute necessity for a healthy room that the window should open at the top, and it is most extraordinary in how many houses, even of the better class, windows are still found with fixed upper sashes.

III.—Materials.

The nature of the materials used in house construction has an important influence on the sanitary condition of the dwelling, and the health of its inhabitants. Walls are generally permeable to air. Professor Graham, in his experiments on the diffusion of gases, showed that this tendency to diffusion was not arrested by enclosing gases in cells with thick solid brick walls. Dr. Pettenkofer and others have made experiments on the passage of air through various materials. He states that in a room with brick walls, of 2650 cubic feet of space, the temperature inside the room being 66° Fahrenheit and 32° Fahrenheit outside, a fire being lighted in a stove, but all openings and crevices in doors and windows being thoroughly pasted up, a volume of air of 1060 cubic feet per hour passed out of the room up the flues.

Dr. Pettenkofer also shews that with a difference of temperature inside the room to that outside of 9° : 5° Fahrenheit, the spontaneous ventilation through each square yard of a brick wall surface was about 7 cubic feet per hour; he does not mention the thickness of wall.

Märker and Schultze, with the same proportionate difference of temperature, found the spontaneous ventilation was as follows, per square yard of surface in walls of similar thickness:

Sandstone	4·7	cubic feet.
Quarried limestone	6·5	,,
Brick	7·9	,,
Tufaceous limestone	10·1	,,
Mud	14·4	,,

This spontaneous change of air through walls is impeded if the walls are damp. Damp walls cause a great absorption of heat from the evaporation of the moisture from their surface. This absorption of heat of course affects persons near the wall, by absorbing the heat from the side of the individual nearest the wall, leaving the other side unaffected. This one sided cooling of the body, or some part of it, is similar in effect to what is caused by draughts of air. It is dangerous from the local disturbance it occasions in the heat economy of the body. The emanations from the human body consist of a considerable quantity of watery vapour, which passes off from the lungs and skin. In a room with damp walls, and without means for frequent renewal of the air, this is confined, and the atmosphere of the room remains at a point of complete saturation. This in newly inhabited houses is frequently the cause of the moisture seen on the walls. The quantity of water which will be contained in a new wall is very remarkable.* Suppose that 100,000 bricks are used for a building, each weighing 7 pounds; a good brick can suck up nearly 15 per cent. of its weight in water, but we will put down at 7 per cent. what gets into it by the manipulations of the bricklayer. We will assume that the same amount of water is contained in the mortar, a quantity certainly much understated, although the mortar forms about one-fifth of the walls; we have thus nearly 100,000 pounds of water, equal to 10,000 gallons, which must have left the walls of the house before it becomes habitable. This water must be removed by spontaneous evaporation into and by the air. The capacity of the air for receiving water depends on the different tension of the vapour at different temperatures, on the quantity of water already contained in the air flowing over a moist body, and finally on the velocity of that air. Assume the average temperature of the year to be about 50° Fahrenheit, and the average hygrometric condition of the air to be 75 per cent. of its full saturation. At the temperature named one cubic foot of air can take up four grains of water in the shape of vapour, but as it contains already 75 per cent. of these four grains, which amounts to three grains, it can only take up one additional grain. As often then as one grain is contained in the 10,000 gallons of water mentioned above, as many cubic feet of air must come in contact with the new walls, and become saturated with the water contained in them; or about 700 millions cubic feet of air are required to dry the building in question. The effect of a fire in drying the walls of a room will be seen from the following instance: take a room of 3,530 cubic feet, and the temperature and humidity of the air at the above given mean averages; as one cubic foot of such air is capable of taking up one additional grain of water, the air of the whole room will take up 3,530 grains, or about half a pound of water. Should there be no change of the air, matters would remain so. But by every fresh 3,530 feet of air coming into the room another half pound of water would be taken up, and so on. Suppose the change amounts to 353 cubic feet per hour, all the moisture we get rid of would be only 353 grains per hour. But if we heat the room to 68°. Fahrenheit, for instance, we increase the tension of the vapour, *i. e.* the capacity of the air for taking up water from four to seven grains per cubic foot, so that each cubic foot of fresh air entering the room is capable of taking up seven instead of four, that means four grains in addition to its original humidity. In consequence of this increased capacity the 353 cubic feet of air take up 1412 instead of 353 grains of water. But by the increased difference of temperature between the room and the open air the ventilation will rise from 353 to 2,100 cubic feet per hour, and in this way we get rid of more than twenty times as much water as if we left the room unheated.

The damp having been expelled from the walls when the house is new, it is their proper function to prevent it entering from the outside. Damp should be precluded from rising into the wall from the ground, as before stated, by means of a damp course, and it should be prevented descending into the wall from above by an impervious coping or eaves. Improperly laid copings will act as conductors of wet into the wall, rather than as protectors against it. Damp should also be prevented from penetrating into the inner part of the wall, either by an adequate thickness of material, in the first instance, or by an impervious outer coating, or by an outer wall, separated from the inner wall by an air space.

---

* See Dr. Pettenkofer's lectures.

The quality and construction of the wall has an important bearing on the maintenance of an equable temperature in a house. The retention of heat is of as much sanitary importance as the prevention of damp. A cold damp house is productive of draughts, and is the cause of rheumatism, bronchitis, catarrh, colds, &c. and a house that requires a great expenditure of money for warming apparatus and fuel betrays a want of skill in the architect.' The conducting power of different materials for heat has some bearing on this question, but the difference in the heat-conducting power of different materials used for wall construction soon disappears when the thickness of the wall is increased, and has little importance when a layer of air is introduced into the middle of the wall. Air when confined in a space between two walls is a most efficient retainer of heat, and therefore hollow walls not only prevent damp entering from the outside, but they retain the heat within the house; consequently economy, dryness and warmth would be best secured by the use of hollow walls, combined, if necessary, with an outer impervious coating. Any arrangement for ventilating the air space in a hollow wall would destroy its efficiency as a non-conductor of heat. The wall, if of brick and plastered over, more or less admits air into the room, or allows of the exchange of air between the room and the outside. It also absorbs the moisture exhaled from the human body, and with it the particles of injurious matter which are constantly being given off from the lungs. Workmen employed in scraping down the walls of wards in hospitals are frequently taken ill from the effects of the deleterious matter they scrape off the walls. Attempts have been made to discover an impervious material for hospital ward walls. The use of glazed tiles for the wall covering is open to the objection that the numerous joints become receptacles of putrefactive matter; parian cement has been tried; but in proportion to the imperviousness of the wall, the watery vapour which emanates from the lungs becomes condensed upon it; and no cement is actually impervious, consequently it is a mere question of time how soon saturation will take place. Probably a plaster wall, of which the face is frequently scraped off and renewed, would be the safest wall for a hospital ward. In private houses the same conditions of impurity exist on a smaller scale. The wall, in process of time, becomes saturated with organic matter, and this is the cause of the musty smell which is found in rooms and houses which have been long in occupation without a thorough renewal of the wall covering. It is this which makes it essential to health that when the wall covering is renewed the surface should be scraped off and a new surface put on, especially in rooms which have been long inhabited.

The materials in common use for roof covering vary greatly in their properties: thus a roof covered with slates, supported on laths, throws off water, but is not impervious to air; if the slates be supported on boarding and laid on felt, or if bedded in mortar, the interchange of air is much more obstructed; if the covering be metallic the roof may be considered practically impervious; and if of asphalte absolutely so. Now while a roof should be impervious to moisture from without, experience shews that it is unhealthy to live directly under a roof impervious to air. Therefore, whilst the outer covering of the roof should be impervious, and the roof should be so laid as to be retentive of heat, there should be a ventilated air space between the porous ceiling and the impervious roof.

As regards floors, one of the most important conditions to be observed in the materials for floors in this climate is that they should not be cold to the feet, consequently wood floors are desirable, unless the tiled floor is arranged so as to be warmed on the old Roman plan. The floor of whatever material it be should always have an air space under it, so as to ensure dryness. The floors should be laid with close joints. If wood floors they should be tongued, so as to prevent the accumulation of dirt liable to putrefy either in the joints or under the floor. This precaution, which in some parts of the country is adopted in work of the commonest class, is generally neglected in London. The frequent saturation of wooden floors with water to keep them clean, has the objection of diffusing damp through the atmosphere of the house; consequently a closely laid polished floor possesses great sanitary advantages.

For windows thick clear glass is of great importance, because a window, if of thin glass, affords a large surface for cooling down the air of the rooms and causing draughts. The loss of heat from one square foot of crown window glass, of best quality, has been estimated to be equivalent to a loss of heat from 14 square feet of 14 inch wall. Of course this is a mere approximation. I hope at some future time to lay before you some facts on the loss of heat through different kinds of glass. Glass is, however, a bad conductor of heat, and thick plate glass is a great safeguard against the rapid cooling down of the air. Double panes have been inserted in sashes to save heat by means of the air space between them; but the difficulty of cleaning the inner surfaces is a bar to their adoption. Double sashes are universally adopted in the north of Europe, and are a most efficient means of preventing loss of heat.

IV.—Ventilation and Warming.

There are two terms applied to ventilation, viz., Natural Ventilation and Artificial Ventilation, which it is desirable should be clearly understood, as the difference is not very apparent. Ventilation is a movement of the air. Anything which disturbs the equilibrium of the air produces movement. The most usual cause of movement in the air which is apparent to us is heat; heated air expands and moves upwards. Every breath of wind is the result of a disturbance of equilibrium by the upward movement of air produced somewhere by the air being warmed. The sun shining will produce this effect: a fire lighted at the bottom of a shaft will cause the direct upward movement of the air over it, therefore this is a natural ventilation. If the fire, instead of being applied directly to heat the air, is applied to a steam-engine to turn a fan, or to send steam into a shaft and produce draught, partly by the vacuum it creates in condensing, partly by the velocity of its movement, and partly by the heat developed, it is called artificial ventilation. In houses it is generally more convenient to confine the arrangements for producing a movement in the air to the effect of the difference of temperature within and without the house.

The principles of ventilation, as regulated by the difference of temperature, are very simple, viz., heated air will ascend, and its place requires to be supplied by air admitted from the outer air. The reason why difficulties are experienced in the application of these principles is because of the various and complicated forms of house construction. A simple case of the difficulty of ventilation is that of smoky chimneys. In some cases the form of the house is such that its staircase acts as a large shaft in which a large volume of air is continually being drawn upwards, and this draws in air from every available opening, and therefore, if adequate provision is not made for the admission of fresh air, it checks the draught which is intended to be established in the chimneys of adjacent rooms. I merely cite this as a simple case. The variety of ways in which the ventilation of one part of the house interferes with that of another are innumerable. It is the province of the architect so to correlate them, that either the ventilation shall act as a whole, or that the ventilation of each part shall act so as not to affect injuriously the ventilation of any other part.

The air of dwellings is rendered impure by the emanations continually given off from the human body. These emanations consist partly of carbonic acid gas, and partly of organic matter, very liable to putrefy. It is moreover polluted by the various processes of cooking, which diffuse a quantity of organic matter into the air, and when artificial light is used, if it be not burned in a vessel separate from the room, it seriously deteriorates the air. It is found as a rule that the deterioration by carbonic acid gas from breathing affords a very safe index of the total deterioration of air in a room by its occupants. The following facts should be borne in mind in considering this question. A man breathes on an average 16.66 cubic feet of air per hour, and produces from ½ cubic foot to ⅔ cubic foot of carbonic acid, besides about half as much watery vapour with organic matter liable to putrefy. Each cubic foot of gas burned produces about 2 feet of carbonic acid. Numerous experiments have been made upon the amount of fresh air which should be supplied to replace the deterioration of air. In England, the Army Sanitary Commission has been foremost in this matter, and very valuable experiments have been made by Dr. de Chaumont, and by other members, of the Army Medical Department. The Army Sanitary Commissioners considered that for barrack rooms, in which, by the custom of the service, the windows are kept open during most of the day, it was sufficient to provide for the renewal of the air during the night, at the rate of 1,200 cubic feet per hour per occupant. The calculation was based on the nominal number of occupants; but in barracks men are nightly absent from every room for guards or other purposes, and thus the volume of air renewed per man sleeping in the room was in reality much more than the nominal amount fixed.

Some of the general results obtained by Dr. de Chaumont and other members of the Army Medical Department, and by M. le Blanc, in Paris, have been collected into a paper, read last August by General Morin before the Academy of Sciences in Paris.

He arrives at the following general conclusions. He assumes that the amount of carbonic acid and watery vapour which is exhaled per individual in ordinary health per hour, and which requires to be removed in order to maintain the purity of the air, is 1.06 cubic feet. In hospitals the average amount is 1.41 cubic feet. For lying-in women 2.12 cubic feet. The amount of carbonic acid assumed to be present in fresh air out of doors is 0.0005 cubic feet; of course this is subject to variation, it is found to be as low as 0.0003 and as high as 0.0006. The amount of carbonic acid which it is assumed may be present without injurious effect in a room is 0.0008. The volume of air which should be removed and replaced by fresh air per individual per hour, in order to obtain a uniform degree of impurity in a room will thus vary with the cubic space of the room occupied by the individual or individuals whose emanations are rendering the air impure. But after the normal degree of impurity in the air in the room has been obtained, then the amount of fresh air required to keep up the equilibrium will be uniform.

The following table shows the amount of fresh air required according to General Morin's conclusions for bringing the air of a room into the normal condition of impurity, viz., to contain the proportion of 0.0008 of carbonic acid:—

Room containing cubic feet.	Amount of vitiated air to be extracted, and of fresh air to be admitted per hour for each individual in ordinary life.
353.2	3178.80
423.84	3108.16
565.12	2966.88
706.4	2825.60
1059.6	2472.4
1412.8	2119.2
1766.0	1766.0
2119.2	1412.8

Thus a bed room 12 feet by 15 feet and 9 feet high, which is generally considered a sufficiently large room for one person, requires, if a proper degree of purity of air is to be maintained in it, that the air should be renewed at the rate of about 1880 cubic feet per hour for each individual occupying it. In a common lodging house, six persons could, under the Act, sleep in such a room; the air to be removed and the fresh air to be admitted for this number will be 11,200 cubic feet per hour. If the room had a fire at bed-time the velocity of air in the flue at about three or four o'clock in the morning would probably, with an ordinary average outside temperature, be about 2 feet per second. An ordinary flue of 14 inches by 9 inches would under such conditions remove about 6,500 cubic feet per hour; but the law makes no provision for flues in sleeping rooms, except in the case of cellars; and, moreover, the absence of inlets for fresh air to replace that drawn off by the chimney flue materially checks the draught in the flue. If in such a room no arrangement is made for the renewal of the air, in a ten hours period of night occupation of the room, the amount of carbonic acid and other emanations from each occupant diffused through the air would be ten times as great as the usual amount in fresh air; and with the six occupants might be fatal. The safeguard in practice against such extreme vitiation is the badly fitted doors and windows, through which some exchange of air takes place, and the exchange is much accelerated by the lowering of the temperature of the outside air during the night.

In rooms occupied as living rooms the air deteriorated by the burning of lights must be provided for in addition to that due to the occupants, and (as shewn above) an ordinary gas burner deteriorates the air as much as six individuals at least. These facts bring home to the mind the importance of providing in a systematic manner for the renewal of the air of all inhabited spaces: that is to say, the removal of the vitiated air, and the introduction of fresh air.

In this country the main engine for the removal of air from our rooms is the open fire-place. With an open fire-place, having a flue 14 inches by 9 inches, a velocity will frequently prevail in the chimney of 10 feet, and in some instances of 15 feet per second, thus causing the removal of from 30,000 to 45,000 cubic feet of air per hour. But as a rule there is no provision whatever made for replacing the air thus removed. It is allowed to find its way into the room as best it can, by crevices in doors and windows and through the walls. We, therefore, perpetually hear complaints of draughts, of colds, &c. Our open fire-places merely warm us by direct radiation of the fire. The hotter we make the fire the more heated air do we send up the chimney, and the more cold air do we bring in to supply its place; thus we are roasted on the one side and frozen on the other, and at least five-sixths of the heat generated by the coal passes up the chimney. All our fire-places on this construction are simply barbarisms. In some houses, especially those of the better class, fresh air is admitted to the rooms to supply the open fire, and to the staircases after it had been warmed at some central warming apparatus. But this system is wasteful of fuel, as it allows the heat from the fire-places to pass up the chimney unused, except for the purpose of creating more draught than is required. Consequently the most sensible form of construction for open fire-places, is one which will utilize some portion of the spare heat which otherwise passes (entirely wasted) into the chimney flue, in such a way as to warm the fresh air required for replacing that which is being carried up the chimney. This fresh warmed air should be admitted into the room in some part where it will flow in without causing a sensible draught. It was on these grounds that the ventilating fire-place adopted in barracks and military hospitals was designed by me.

In a room in which there is an open fire, the air near the floor level is drawn towards the fire, a portion passes away up the flue, but the remainder is carried up in front of the chimney breast, and thence it passes along the ceiling to the end of the room opposite the fire, when it is drawn out to supply the place of that which is passing along the floor to the fire. The air is thus in continual circulation, and the place at which fresh warmed air can be admitted with least disturbance to the currents and least perceptible effect is high up in the chimney breast. I, therefore, selected that place for the admission of the fresh warmed air, because any inflow of air, even at a temperature of 70° or 80° will be felt as a draught if it impinge on any part of the body. It will thus be seen that this fire-place, whilst it provides for the extraction of a sufficient volume of air from the room, provides also for the admission of an adequate supply of fresh warm air to replace that which has been removed. It preserves an equable temperature in all parts of the room ; it will afford the same amount of heat as a well constructed ordinary fire-place, with one-third the amount of fuel; it will not smoke, and when there are two fire-places in the same room, of which only one is lighted, it will prevent down draughts in the unused chimney flue.

In towns, and especially in London, the air is rendered so impure by soot and other matters, that any current admitted continuously at one place soon blackens the adjacent walls and ceiling. The only remedy for this is to pass the fresh air to be warmed in the chamber at the back of the fire, through a filter of cotton wool, to remove the blacks and other impurities. This plan is shewn in the diagram.

In Germany close stoves are generally used; frequently the stove is filled with fuel at an opening outside the room, and no removal of air takes place by means of the stove. In German rooms, therefore, the purity of the air is frequently left to depend on the spontaneous change of air which can take place through crevices of windows and doors, or through the walls. This absence of ventilation is the cause of the saving of fuel in German stoves. This saving of fuel, however, is at the expense of health. Dr. Böhm (than whom no one has better studied ventilation) has adopted for some years the following system in the Rudolf Hospital at Vienna. He there warms fresh air by means of passages constructed in the fire-clay stoves, placed within the ward, and the fresh warmed air passes into the ward from the top of the stove. He provides flues of a large size, and proportioned to the size of the ward, from the level of the ward floor to above the roof, and the difference of temperature between the air in the ward and the outer air causes a sufficient current in these flues to ventilate adequately the ward. By this means the fresh warmed air, instead of passing off to the upper part of the ward, and thence away by flues, is made to circulate towards the floor of the ward, thus bringing into action the principle by which the open fireplace is useful in ventilation. But this arrangement destroys one element of economy in the German stove, because the heat generated, instead of being left to pass slowly off into an unventilated room, is removed rapidly by the fresh air passed into the ward, and has, therefore, to be renewed at intervals, instead of, according to the usual custom, the stove being left shut up for twenty-four hours to give off its heat slowly. The larger the supply of warmed air, the larger must be the consumption of fuel; and if the heat is to be supplied economically, it must be through a good conducting medium ; but the material of the German stove is a bad conductor of heat.

The old Roman system of warming by means of a fire under the floor produced a most agreeable and equable temperature; but it did not assist the ventilation, and it was not economical, in that the floor, being of tiles, was formed of a bad conducting material, and much of the heat was absorbed in the ground or surrounding flues. According to Pliny, the smoke was carried to the wood-house, to be used in drying the wood for burning. I recently made an experiment, to compare the effect of warming by means of a heated floor with the heating effect of a ventilating fireplace. The experiment lasted with each mode of warming for two days. It showed that, in the case of the warmed floors, the room was maintained at a temperature of about 18 degrees above the temperature of the outer air with an expenditure of 56 pounds of coals and 112 pounds of coke; whilst with the ventilating fireplace the expenditure was only 75 pounds of coals, the cost being 3s. 4d. for the warmed floor as compared with 1s. 4d. for the ventilating fireplace. If a good conducting material could be selected, the results ought not to be so unfavourable to the floor. When the room is heated by a warmed floor, the ventilation should be obtained by arrangements near the ceiling, such as a perforated cornice, or a Sherringham ventilator. The cold fresh air would pass in, and sink down gradually to replace the warmed air which would pass up from the floor. The open fireplace, or its substitutes, in connection with proper arrangements for admitting fresh air, afford ventilation and warming in houses where each room is made self-dependent.

The ventilation and warming of the whole house may be provided in a combined systematic plan from one fire. In such case the uniformity of temperature in the rooms should be secured by drawing off the air contained in them from the floor level, and admitting the fresh warmed air at the ceiling level; in fact, the conditions of ventilation of the open fireplace should continue to be observed. With this systematic arrangement a much greater degree of uniformity can be obtained than with the open fireplace. The volume of air removed and admitted can be regulated to the greatest nicety, because the velocity can be so arranged as to be uniform and not variable, as must happen with an open fireplace. But to ensure uniformity, the area of the inlets and of the exhausting flues must be carefully proportioned to the velocities intended to be obtained and the volume of air to be removed. Moreover, a separate flue should be provided from each room, and the flues should be as little circuitous and with as few angles as possible, and they should be capable of being easily cleaned. As regards economy, these combined arrangements are very plausible in theory, but, in this climate especially, where variations of temperature are so frequent, and the winter is often very mild, it is questionable whether economy is not best obtained by making each room self dependent for warmth and ventilation. Such separation is undoubtedly safer in a sanitary point of view.

The arrangements above described are suited to rooms occupied by a limited number of persons: in the case of rooms required to contain large numbers of people, and to be lighted by numerous candles, etc., the large volume of air to be removed to preserve freshness presents features of greater difficulty. Rooms designed for ordinary every-day life are not suited for the reception of large numbers of people. Rooms for this purpose should be provided with exceptional arrangements for removing and renewing the air to a far greater extent, and for protecting the air from the impurities of artificial light. In all cases the impurity of the air caused by artificial light is very serious; and the conditions which are required for the maintenance of a uniform temperature in a room by means of an open fireplace conflict with those conditions necessary for the removal of the products of combustion. It is most important to the purity of the air of a room that the products of the combustion of gas should not mingle with the air. Several forms of lights have been designed for this purpose, but as a rule they do not entirely fulfil their object. Thus, if a sunlight is placed in the ceiling, its action is to carry off a large volume of air from near the ceiling; an open fireplace in the room draws a large volume of air towards itself. The currents conflict, and the fumes from the sunburner are liable to be drawn into the room. In the case of a gas globe lamp suspended in the middle of the room, supplied with fresh air from the room, with a pipe to carry off the fumes leading from the light up to the ceiling, and along the ceiling into the chimney, the smallness of the pipe, the bend, and the horizontal length, all contribute a large amount of friction to diminish the draught in the tube; in rooms where there is no arrangement for replacing the air removed by an open fire, cross currents will sometimes prevail in the chimney flue, especially if it is large. Whenever the draught in the tube is sluggish, the fire in the chimney draws down some of the fumes directly towards the fire; consequently it is very rare that, even with this class of burner, the fumes of the gas are removed. The only safe plan is to place the gas burners in a globe entirely cut off from the room, supplied with fresh air directly from the open air, the fumes being also carried directly into the open air. Such an arrangement is very simple in the case of an outside wall, and this is the only system which will keep the air of a room free from the fumes of gas. This arrangement has been for some time in use in my own house.

I have thus endeavoured to lay before you, in a concise manner, some of the sanitary considerations which should regulate the construction of human dwellings in reference to the health of the inhabitants. I will mention one fact in illustration of the effect of the introduction of healthy constructional arrangements in dwellings, viz.: the results of improved ventilation in barrack rooms. Before ventilation was introduced the deaths of Infantry of the line at home, from chest diseases, were 10.1 per 1000 men In 1871, when ventilation had been introduced, the deaths from the same causes were only 3.3 per 1000. Or to put it in another way, the effect of the defective architectural arrangements of our barracks upon an army of 100,000 men used to be to kill unnecessarily in every year 700 men, which is equal to the strength of a whole regiment; in addition to these deaths, the defective arrangements rendered a far larger number of men inefficient from sickness. The statistics of the effect of insanitary construction in injuring the health of the civil population are not so easily traced; but the reports of medical officers of health shew that it is at least as serious.

I have advanced no new theories. The laws of sanitary science are simple; but their application is frequently complex. At the present time Parliament has under its consideration the improvement of the sanitary administration of the country. In such administration it is highly probable that important functions will be given to the local surveyors, who would necessarily be architects by education and profession. But the architects of England have a more serious responsibility than that of merely assisting in sanitary administration. Their mission is to set an example, by designing and erecting houses on strictly sanitary principles. They are the pioneers and the instructors of the whole nation in the rules for the construction of healthy houses; and when the knowledge they disseminate has borne fruit in the community, all persons who build either houses or cottages will be compelled to follow their example. Architects, far more than medical men, are the arbiters of the health of the community; and this fact is my apology for bringing these subjects before your notice to-night.

Mr. THOMAS HENRY WYATT, Past-President, said,—As an old member, and an old friend of Captain Galton, I would express my own opinion, which I am sure will be shared by all present, as to the obligation which Captain Galton has conferred upon us by giving us the result of his great experience. This is not the first time he has explained his views. He claims no credit for novelty; but I believe that Captain Galton, when at the War Office, was one of the first pioneers of sanitary arrangements in barracks; and I am glad to find that in the change to a position more immediately connected with our profession he continues these researches, and I venture to think we should feel grateful to him for coming amongst us and engendering that strong feeling which ought to animate us on this important subject. Although there are difficulties in carrying out his suggestions, which are known only to architects, yet, with increased feeling on the subject, and with the advantages which he and other scientific men have given us by their practical experiments, I think it would be a great reproach to us if we do not assist them ourselves to the utmost of our power. No doubt there are members present who will make some valuable observations. There are some points which require explanation, and others on which possibly difference of opinion may exist; but for the present I beg to propose a cordial vote of thanks to Captain Galton for his paper.

Professor KERR, Fellow, upon being called upon, said,—I cannot say that I have paid particular attention to the subject of the lecture, but I have paid some attention to a subject of collateral interest, that is, the responsibility of the architect in respect of all those constantly augmenting demands which are being made upon his skill and care. I am afraid our sanitary reformers will improve us off the face of the earth. Architects have a great deal to do besides attending to these sanitary matters; and if Captain Galton would be but kind enough to say that the fault as regards unwholesome houses lies somewhere else, we should be much obliged to him, and I for one would not trouble him to say precisely where it lies. But seriously speaking it does not lie with the architect. I may say I have an extensive acquaintance with architects of a good many classes, and I have generally found all of them to be actuated by a sincere desire to do the best they can in this as in all else. But the difficulty of introducing refined sanitary considerations in connection with the ordinary sordid proceedings of building is extremely great. At the same time we are, I hope, sufficiently intellectual and sufficiently interested in the subject to appreciate the great value of the paper we have heard. I think this is the first paper I have listened to on the subject which fully and exhaustively, and without a superfluous word, sets forth the whole practical question which is before the public with regard to sanitary considerations. I think the paper will enrich our transactions, and we are much honored by Captain Galton coming here and laying before the public through our means an essay so full of suggestions and so full of practical experience. The details of the paper are so numerous, that I am afraid, notwithstanding what Mr. Wyatt has said, there may not be many of us prepared to discuss even the principal points which Captain Galton has raised. It seems to me, however, there is one other field in which so expert a sanitarian might occupy himself. Let him take houses as they are, and see what can be done with them without alarming the public, and without placing insurmountable obstacles in the way of architects. To get builders of houses, or the occupants of them, out of the ordinary groove is practically impossible, as we all know; and if we look at great public buildings, where some opportunity might be considered to be afforded for the exercise of great gifts in respect of such matters as warming and ventilation, I think generally we find that if the architect indulges in any "crochets" (for so they are called), the occupants will find them out and prevent them from being put into operation. In country houses for example, if the architect ventures to ventilate the bed-rooms, the ladies will very soon stop the ventilation, and we must ask Captain Galton to accept that kind of thing as a primary condition out of which we cannot escape. If he would take up houses as they are, therefore, and tell us what to do with them, I am sure we might receive from him some sound practical suggestions.

Mr. C. BARRY, Fellow,—I join with great pleasure in the expression of our acknowledgments to Captain Galton for his paper to-night. He has told us truly he has advanced no new theories. He has however dealt with facts and experiences with which no one is perhaps better acquainted than himself, but the difficulties of dealing with which we, as practising architects, have perhaps more personal knowledge than he. He is in the enviable position of being able to lay down principles without having the responsibility which lies upon a great many of us to carry them out in the face of the difficulties which surround us. For instance, Captain Galton drew a parallel in the early part of his paper between the erection of public buildings by a public department, instancing barracks, and the functions of architects in erecting private houses, a parallel which I confess I am unable to recognize. He told us that when barracks have to be built, the commanding officer of the district selects the site, and doubtless he should be qualified to do so from his residential local knowledge; that then a Royal Engineer officer reports upon the position, its surroundings, approaches, etc., and it would seem to lie within the province of the Engineer to override the judgment of the commanding officer, and I rather think Captain Galton could tell of instances known to him in which that has been the case. Lastly, there is the special medical officer to give his advice as to the healthiness or otherwise of the locality fixed upon, and his report in that respect might go against that of the engineer, and sometimes has done so. Again, in these cases all the officials work with an unlimited public purse, and if one locality is pronounced under all the above considerations to be unsuitable, another is chosen; hence, we have indeed a right to expect that, as regards such buildings, the most perfect conditions will always and inevitably be secured. Whether this has always been the case with military barracks may be matter of opinion with us all; but when conditions are laid down so minutely and so elaborately, and opportunities to avoid error are so available, we might hope that anything like failure in any of the above important particulars would be impossible. Not so, however, is it with the architect. He is called upon to deal with circumstances ready made. There is no choice of locality by the district commanding officer; there is no engineer to say this or that is the best position; nor is there the medical officer to testify to the salubrity or otherwise of the site; but the architect has himself to act in all these capacities so far as it may possibly under the circumstances, and he must deal with the position as he finds it, and make the best of it. Therefore I say that the parallel which Captain Galton has drawn scarcely holds good, and that there are extenuating circumstances for the architect acting for private clients or public bodies which do not apply to the special public works referred to. So far, in defence of our possible shortcomings under the ordinary difficulties of construction and position. Again, in the case of barracks and other like public buildings, sanitary science prescribes that a certain number of cubic feet of space is desirable for health, and all sanitary arrangements, and the number of occupants are perfectly under control; but here again there can be no comparison with the case of an architect designing a private dwelling. There is no possibility of his knowing beforehand how many or how few persons an apartment will contain at one time or another: he only knows that it will be sometimes empty and sometimes crowded, and that therefore the most perfect scientific arrangements applicable to the one condition are useless, and even mischievous to the other. For instance, the ventilating arrangements suitable and efficient for a drawing room ordinarily occupied by five or six members of the family, would be totally inadequate when the same room was crowded with people on the occasion of a dance or large ball, and yet this is of course of constant occurrence. It is difficult, and all but impossible, to make the arrangements under such circumstances suitable to all the cases in which they would have to be tried, and whatever ingenious arrangements may be made, there is little probability of their being understood and always intelligently used. Here, therefore, again architects may truly plead that they have difficulties to confront for which due allowance is not always made.

For the valuable paper which Captain Galton has brought before us to-night, I feel nevertheless that our obligations to him are great, because, although he says he has advanced no new theories, yet I hope I may assume that he sympathises with us to the extent of believing that we do give some thought to the several subjects enumerated, and he has at any rate formulated them in a shape which will be of much use to those who wish to study the subject, or compare their experiences with his. I would lastly allude for a moment to the last subject in the paper, to which Captain Galton has given his personal attention, viz., the particular stove which bears his name. We shall, I think, not fail to see that it is one which is likely (as he says it is in practice) to be extremely efficient for the objects for which it has been designed. Its author has, however, claimed for it one excellence which, if invariably maintained, would surely make his fortune, viz., that it cures all smoking chimneys. If this stove accomplishes this, it has solved a question of the greatest possible difficulty, and of the greatest possible moment in the present day, and the Galton stove should make its author's name immortal.

Mr. William White, Associate, said,—Mr. Barry opened his remarks with a sad picture of the responsibilities and difficulties of architects in the selecting of sites which Captain Galton has laid before us. But I was reading some remarks upon the new proposed Sanitary Bill, which I understand is soon to be brought forward. Now, if that is brought forward in the manner in which I saw it laid down, we shall have all these difficulties and responsibilities removed, because they will be thrown entirely upon the local medical officer. That is the way in which I read the remarks upon this bill. We can therefore only hope that the medical officers will be as efficient in their office as Captain Galton has been in his; and perhaps instructions may have emanated from him to show what their office ought to be. At present certainly there are great difficulties and obstacles to encounter in the ventilation of rooms.

I had intended myself to make a remark with respect to this room, and to say that I should be glad if Captain Galton would try his hand upon it, so as to give us a little fresh air at our meetings. From what he has said, I have made a calculation that we must consider, according to the number of lights in this room, we have an addition of equal to 150 people besides what we are at present; and if that is so, it requires a larger amount of ventilation than we have. I have not myself experienced the objections to ventilation on the part of ladies which Professor Kerr has mentioned, for I have found that they do not only not object to it, but they almost insist upon it, and I have consequently turned my mind to it, and I have found a simple and efficacious mode of ventilation which, if you will allow me, I will sketch the principle of on the board. [Illustrating.] It is ventilation into the outer wall by means of a double flap, or rather hopper, and a division between; the air being brought in by the lower flap from a flue at the bottom, which gets warm before it reaches the people in the room, and the hot air is drawn out through another flue at the top. [A Member,—How does it get warm?] By the warmth of the room; and there is a continual change of air going on. A few weeks ago I put half-a-dozen of these ventilators in a room where we have had an evening service for some years, and now for the first time since the same was held we had no streams of water down the windows. That was a fair test, and it did make a great difference to the comfort of the people in the room. I think Captain Galton's grate seems an admirable contrivance for preventing that stagnation of air which is so destructive of comfort in a room: indeed, I have often used in schools something of the same sort.

Mr. WOODTHORPE, Fellow,—That the sad state of this room has been commented upon is a great satisfaction to me. I assure you that I have been nearly roasted on one side this evening from the excessive heat of the fire, and I join very heartily in the proposition that something should be done to make this room tolerable to the members. I know many who will not enter it on any consideration, and other members have a great objection to do so on account of the defective arrangements, and it is clear that as our numbers have very much increased, something ought to be done to give the members a more comfortable and wholesome room. The seats are so inconveniently arranged, that if a talented youth rises from behind to speak you have to hoist your neck round to a painful extent to hear and see him. I think the remarks made on the subject before us will cause the Council and members to think seriously of improving the ventilation and accommodation by alteration, or removal altogether to a building more adapted to the uses of modern society.

Mr. C. BARRY, Fellow.—The subject of ventilation, like many others, depends upon finances. There is, we know, such a body as the Architectural Union, who own these premises. The Institute is only a tenant, and pays a certain amount of rent, and there are rooms over this ceiling which produce rent. I have no doubt the Architectural Union will be happy to make terms for the hire of the rooms above for the purposes of ventilation.

Mr. T. CHATFIELD CLARKE, Fellow,—I would ask Captain Galton to be good enough to help me in one point with regard to the question of ventilating gaslights, and I would ask him whether he has found, in the case of sunlights, that the tubes get very hot, and that that form of light draws the air from other parts of the room and causes draughts. [Captain GALTON,—The gaslight to which I referred in my house does not communicate with the room.] It is an objection to sunlights that both the inner and outer tubes get very hot, and the sunlight then is fed with air from all parts of the room.

Does Captain Galton propose to introduce air to the upper part of the room to feed the sunlights? I have been told that the air will descend on the heads of the people, and then form an upward current under the sunlight. In offering these remarks I beg cordially to join in the vote of thanks to Captain Galton for his clear and able paper.

Mr. Robert Rawlinson, C.B., Visitor, responding to the President's invitation, said,—I think it will be hardly worth your listening to what I can say after the very able remarks which Captain Galton has laid before you, because you do not want me to say ditto to what he has said, and I am scarcely able to supplement what he has so clearly and practically stated to you. The question has, however, been asked as to what may be done to remedy existing defects in houses. That is a very important question, and I think it devolves upon architects to find a practical remedy. With respect to house drainage it is perhaps a bold thing to say with regard to London, that taking the main sewerage, it is at this moment sewered more perfectly than any great city in the world. But even these sewers are not so perfect as they might be if we had to do them over again; but the drainage of the houses in London, taken as a whole, is bad.

Within the last two years friends have called on me to look at their house drianage. The defects I find are these:—very frequently the basement is ramified with the drains, and honey-combed with cesspools. If the houses are more than forty years old these drains have been built of loose bedded brick, square on section on the subsoil, which if of gravel is porous. Many drains run from back to front, and where there is a sink or closet there is usually a cesspool to catch any sediment, under the idea that such cesspits prevent the drain choking. This arrangement is about the worst possible for the drainage of a house; as absolutely there should be no internal cesspools nor cesspits, and if it is possible so to arrange it, no drain should be within the four walls. If, however, it is not possible, then the drains should be made air tight and water tight, and be ventilated back and front. I do not quite agree that a drain should be exposed that it may be examined, because I would bury it in concrete, and have an opening on both ends for ventilation and occasional flushing. I would so construct it that it should be impossible to leak or give out any sewer gases into the building. With regard to ventilating rooms, as a rule, these are made for domestic uses only, and as one gentleman has said, there is that difficulty. When we invite a large number of people into a modern house and overcrowd it, we are liable to do an amount of mischief it is impossible to calculate. I am not much of a company keeper myself, because in my house I have no arrangements such as will enable me to give comfortable accommodation for 150 people in rooms usually occupied by three. Whether it is possible to arrange modern houses so that we shall be able to give equal comfort to the resident family and equal comfort to the flood of visitors I am not at present prepared to say.

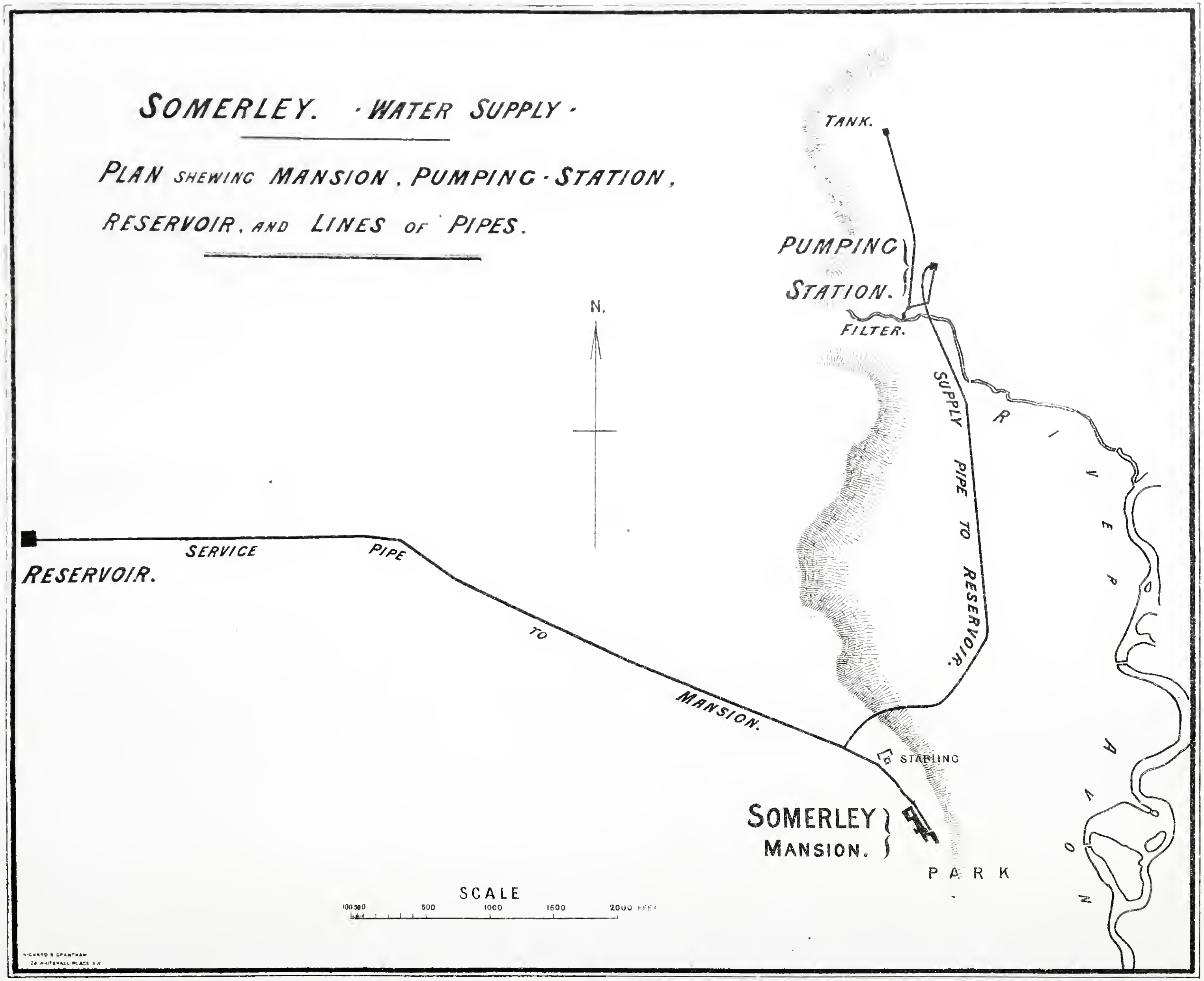
If I were going to build (and now perhaps I am going to expose my ignorance) I should construct every door space from the floor to the ceiling, putting the lintel in as at present; but I would take care that there should be an open space up to the ceiling available to do what I wished with it by finishing the same either with sliding panels or otherwise. I would have space above at the ceiling to communicate with the corridor and staircase, which ought to be the lungs of every house. These fine-spun theories of ventilating flues and extracting shafts are difficult to construct and difficult to manage. I may expose myself to some ridicule by the suggestions I have made, as I should be told such a house will be full of draughts. I can only say that there is not a man in the room more delicate in constitution and more sensitive to draughts, and who requires more warmth than the person who is now speaking to you, but I am equally sensitive to vitiated air as produced by stagnation. Therefore in making arrangements in my house to secure fresh air, I am obliged to make arrangements to secure warmth and free myself from direct draughts. I do it in this way, In the first place I have removed every drain from the basement; I take care that the sewers and drains are ventilated; all my closets are against external walls, and I have a fixed opening to the outer air, which neither I nor any member of my family can close. These are open in the bitterest weather as in the warmest. In the cloak room I have free ventilation through a space 12 inches by 6, I can shut the cloak room door when the warming apparatus is going, but I do not stop ventilation. Another fault in modern houses is that there is seldom any ventilation for the apartments on the upper stories, and as Captain Galton says, the warm air from below ascends, the result being that the upper stories become unwholesome, choky, and very unhealthy. A simple remedy for this is provided by making the flap through which you get on to the roof a ventilator, so as to have a constant renewal of the air there. Frequently, housemaids' closets are put into some inner room or space without ventilation, and the sink pipe goes down into the drain, and that becomes a tube for carrying back the gases which are evolved. Then, again, if the closets cannot be placed against an external wall, a shaft should be carried up through the roof, so as to get a change of air there. In noblemen's houses occasionally you have closets near the bed rooms, and if there are no arrangements for external fresh air ventilation they are sure to be a nuisance. Some gentlemen have been talking about the lecture room. It is several years since I was here last; I protested against it then, but I find no improvement.

In improving the drainage of old houses, cesspools and cesspits are removed; that is, they are emptied and filled with concrete. If the square brick drains are sound the cover is removed, they are cleaned out, and if the dimensions will admit a drain pipe is laid in, bedded in Portland mortar or concrete, and covered with similar material.

The President.—In conveying to Captain Galton, on behalf of this meeting, our best thanks for his paper, I will make but one remark. My own opinion is that which has already been expressed with regard to the extreme value of the paper. Two of the principal speeches made this evening have been of an apologetic character—apologies for our profession not doing one part of its duty. I am sorry to say my own conscience thoroughly makes good what those gentlemen observed; and in excusing ourselves, and at the same time accusing ourselves, really we admit the truth of what has been said; and I think it is our duty, now that the matter is brought before us in so admirable a manner, to do our best in spite of all difficulties, which we appreciate, to ameliorate our practice in that respect. I beg, Captain Galton, to accord to you our most hearty thanks.

Captain Galton said,—I am extremely glad if anything I can have said has been felt as likely to be of any service to men of so much talent and reputation as the members of this Institute. With regard to the questions put to me, I was asked whether I would make any suggestions as to the improvement of houses as they are? The whole of my sanitary education took place in trying to improve buildings which were in existence—viz. barracks. When I first began to study sanitary matters, which was immediately after the Crimean War, the question was raised whether all then existing barracks should not be pulled down and rebuilt because they were so bad. I strongly advised Lord Herbert (Mr. Sidney Herbert in those days) to endeavour to improve the existing barracks, and the result of that improvement has been the reduction of the death-rate of the army from what I have told you, from chest disease, from 10 per thousand to 3. That was with the existing buildings. Very few new barracks have been constructed. That ventilating fireplace was really designed solely to meet the objection of the soldiers to admit any ventilation at all. Whenever we endeavoured to admit fresh air into a barrack room, the soldiers immediately stopped up the opening, and we were driven from one thing to another, till at last, necessity being the mother of invention, I devised this stove, which lets in warmed air in a position in which the men could not feel any draught at all, and that really constitutes one of the chief merits of the fireplace. It is not the subject of any patent, and it has been in use now for the last fourteen years in barracks, and there are about 10,000 of them in use in barrack rooms and military hospitals. With regard to smoky chimneys, the reason why that form of grate does not smoke is—first, because you get in a sufficient quantity of fresh air into the room to prevent the draught being checked by the conflicting ventilating arrangements of the other parts of the building; and in the next place, the short iron flue which connects the grate with the brick flue becomes rapidly warmed, and that always creates a sufficient draught: therefore it does not smoke—first of all, because of the short iron flue, which is smaller than the rest of the chimney flues, and next because sufficient air is admitted into the room to prevent the draught of the chimney being checked. One gentleman suggested some questions with reference to the Act of Parliament recently passed by the Local Government Board. I have nothing to do with the Local Government Board myself, and am in no way concerned with it. With regard to the question as to sunlights for gas when you have open fireplaces in rooms, it seems to me that the sunlight necessarily presents great difficulties, because the draught of an open fireplace is in open conflict with the sunlight and the currents which it creates, and it was on that account I employed that particular ventilated gaslight which I have adopted in my house. Nor is that a patent, but I devised it merely to prevent the fumes of the gas injuring the air of the room. It is fed by fresh air from outside, and the fumes are carried to the outside: there is no communication whatever with the air of the room. There is just this little difficulty about it: it is necessary to light it, and that in my house I do by a small electric battery, so as not to have the trouble of taking off the globe. It keeps the air of the room perfectly pure. I am sure all the members of the Institute will join in the expression of satisfaction at seeing Sir Gilbert Scott in his place after a temporary absence for the benefit of his health, which I trust is now restored.

The vote of thanks was then passed by acclamation, and the meeting adjourned.



SOMERLEY. ·WATER SUPPLY·

PLAN SHEWING MANSION, PUMPING-STATION, RESERVOIR, AND LINES OF PIPES.

Photo-Lithog^d. for the R.I.B.A by C.F. Kell, London.

Royal Institute of British Architects.

At the Ordinary General Meeting, held on Monday, the 26th of January, 1874, the following Papers were read, Sir G. GILBERT SCOTT, President, in the Chair:—

ON WATER SUPPLY FOR COUNTRY MANSIONS.

By R. B. GRANTHAM, ESQ., M. Inst. C.E. F.G.S.

I HAVE had much pleasure in acceding to the request of your Council to present you with a paper on this subject, as I have had some experience in the execution of works of the kind, and have always felt great interest in the question. We must all admit the great importance of providing large establishments not only with a good, wholesome, and abundant supply of water, but also with a means of protection from the destructive agency of fire, more especially in the case of large mansions, so many of which possess historical interest, and contain works of art of incalculable value. With these two questions I propose to deal as fully as I can within the limits of this paper.

I would here venture to express my sense of the importance and desirability of architects and civil engineers working together and aiding each other in the respective branches of their professions. I myself may claim a connection with your profession, for in early life I was a pupil of the elder Pugin, with whom I was placed for the attainment of so much of the principles of architecture as was necessary for the education of a civil engineer; and I long after enjoyed Mr. Pugin's acquaintance and friendship.

In dealing with my subject I propose to describe:—

1. Sources of Supply of Water.
2. Quality.
3. Quantity.
4. Modes of Supply.
5. Details of Fire Service (an example)
6. Destruction by Fire and instances of Prevention.
7. Necessity for adopting a Fire Service.

There are many very large establishments such as hospitals, barracks, prisons, union-workhouses educational institutions, &c., situated in isolated positions and in which large numbers of persons are lodged and maintained, where a good and abundant supply of water is of the greatest importance and necessity, both for consumption and as a protection against fire. In addition to these objects of first importance, I may enumerate others, such as the many purposes of ornament or pleasure served by an ample water supply, as well as its absolute necessity for the successful prosecution of horticultural pursuits, and its great value in cases where large numbers of cattle and horses are kept in situations where great labour would be necessary in pumping the supply or conveying it from a distance.

Scarcely a year passes in which this subject is not brought forcibly home to our minds by the destruction by fire of several beautiful and time-honoured mansions and country seats, owing to the want of a supply or storage of water, or, where this exists, to the absence of the proper means of applying the water to the part of the building first endangered.

In most towns provision is made for extinguishing fires by means of a high pressure service, and fire engines; but mansions and other buildings situated in isolated and remote places, are of course dependent upon their own resources, even for manual labour. It is very remarkable how few private houses in towns are ever totally destroyed by fire, although in warehouses, manufactories, shops, and frequently in churches and chapels it is of constant occurrence, and often with the most destructive results. The modern furniture in which so much light fabric is employed would, moreover, seem to afford a ready means of originating and spreading fires; but many doubtless occur which are speedily extinguished and not publicly known.

Sources of Water Supply.

The rain-fall is the source from which all water is derived, and although for the purposes of this paper it will not be necessary to enter into any calculations as to the amount of water that can be obtained from the rain-fall in any particular district, nevertheless I venture to think that a consideration of the geological order in which the water bearing strata occur, and a glance at the chemical analysis of the water, will not be out of place in a paper of this kind.

A geological section presents to us a series of rocks alternating with beds of gravel, sand, and clay, and we know that these various strata follow each other in regular succession, except where faults or geological disturbances have taken place. With a knowledge of these facts we are frequently enabled to ascertain approximately the depth at which the water-bearing strata may be met with.

The rain falling on the earth's surface is partly absorbed by the soil, partly evaporated, and partly conducted away over the surface, to form streams and rivers which ultimately reach the sea. These operations will depend of course on the nature of the surface on which the rain falls, and the temperature of the atmosphere at the time.

That part of the rain-fall which is absorbed gradually, finds its way down through the fissures and cracks of the underlying strata, and forms there a vast subterranean storage, until it is checked by meeting with beds of clay; or if the underlying strata be clay, it will either slowly permeate through or be thrown out on the surface of the land. In the former case if the more porous strata be of little depth it will soon be full of water which will then escape, and may be collected from the sides of the hills. If the strata consist of great thicknesses of rock, it will find its way down through the fissures and cracks.

In the geological order the first strata that we meet with are the drift of tertiary beds of gravel and sand of which the Bagshot sands form a part. These superfical beds absorb large quantities of water, and as they are often alternated with bands of clay, the water is thrown to the surface in the shape of land springs. Where the country is open and uninhabited, the water from shallow wells sunk in this strata, is generally found to be good enough for domestic purposes. But where the ground is covered with habitations it becomes contaminated from the putrescent organic matters, which owing to the porous nature of the soil, are sure to find their way into it. So much of the water as is not returned to the surface in springs, sinks into the chalk which underlies the superficial drift beds. This as you are aware, is the great water bearing stratum for the larger portion of the South of England. The water in it can be obtained either by means of ordinary shafts, or by artesian wells bored sometimes to great depths, and from which the water will frequently rise to the surface. It is well known that the level at which it may be found in this stratum is a matter of calculation. "Take the level of the highest source of supply, and that of the lowest to be found. The mean level will be the depth at which water will be found at any intermediate point, after allowing an inclination of at least ten feet per mile." This method of calculation will also apply to the green sands. Below the chalk the upper green sand is reached. This formation contains large quantities of water which is more evenly distributed than in the chalk. The gault clay is interposed between the Portland beds and the lower green sand, which also furnishes good supplies. In boring into the upper green sand, caution should be observed so as not to pierce the gault clay, because water which permeates through that system becomes either ferruginous, or contaminated by salts and other impurities.

The next strata in which water is found are the upper and inferior oolites, between which are the Kimmeridge and Oxford clays, which are separated by the coral rag. Now there are instances in which the Oxford clay is met with immediately below the Kimmeridge, rendering any attempt at boring operations useless, because the water in the Oxford clay is generally so impure as to be unfit for use. And with regard to finding water in the oolitic rocks, it is impossible to determine with any amount of precision the depth at which it may be reached, owing to the numerous faults which occur in the formation. It will therefore be necessary to employ the greatest care before proceeding with any borings. Lower down in the order are the upper lias, the marlstone, the lower lias, and the new red sandstone. In the marlstone between the upper and lower beds of the lias, there may be found a large supply of water, but the level of this is as a rule too low to rise to the surface through a boring. It will be necessary to sink shafts in the ordinary way to reach it. In the new red sandstone also to find the water, borings must be made to a considerable depth. Underlying the new red sandstone is the magnesian limestone, followed by the coal measures, the millstone grit, and the mountain limestone, below which are the silurian and cambrian systems. In the magnesian limestone and coal measures water may be found, but the older formations do not yield much. As, however, they are often at a great elevation, it may be collected from their surfaces by means of reservoirs.

I should add with regard to boring that water will not always be found as is commonly supposed in the same stratum at the same depth. Owing to the faults and disturbances which have taken place, the level of water in various basins of the same formation is found to vary considerably.

QUALITIES OF WATER.

Having described the sources from which water may be obtained, I will now endeavour to point out the qualities of water best suited for the various domestic uses for which it is required.

Dr. Voelcker, in a lecture before the Royal Agricultural Society, alludes to the four essential qualities of water intended for household use, viz. absence of putrescent organic matter, absence of discoloration, softness and coldness.

The qualities of water vary very considerably. The softness of water is a quality much sought after. This property is found to vary according to the source from which it is obtained, some districts supplying soft water (which is the purest form) others affording hard water. Those waters which come from the chalk or limestone formation are invariably hard, varying generally from 16 to 20 degrees of hardness (Clarke's scale); that is, so many grains of carbonate of lime in a gallon. These upon boiling will leave in a short time a thick deposit or fur upon the inside of boilers, kettles, &c., but by the process the water becomes softer in proportion to the lime precipitated. Waters from the green sand and new red sandstone formations are probably the purest and softest of any of the kinds which are drawn from the earth, but the softest and those containing the least degrees of hardness are those which are gathered from elevated and mountain countries and lakes having 4 to 5 degrees of hardness only, but they usually contain some organic substances, and are frequently tinted with the colour of the herbage or soil on the surface of the land from which they have been gathered; except in appearance however this water is the best for clothes washing, boiling, tea making, brewing, &c., while the hard and well aerated waters are more sparkling, fresh, and agreeable to drink.

This leads me to the subject of filtration. The materials generally used for filtering purposes are sand and gravel and animal charcoal. It has been found however by experiment that the pores of the charcoal, although it absorbs organic matters for some time, will sooner or later become clogged, and will cease to arrest those matters, and not only does the charcoal cease to act, but it will return the matters which it at first absorbed. However, for small filters where the material can be replaced or reburnt it will answer the purpose. For filtering reservoirs sand and gravel of various sizes have been found the best medium. The sand must not be too fine lest it should become choked, and it must be freed from admixture with all ferruginous and other matters.

It is worth while to mention a curious fact in connection with open reservoirs. It has been observed that in shallow reservoirs there has been a growth of confervæ, and on the decay of this, animalculæ have sprung into existence. But this does not occur in reservoirs containing a depth of 15 to 20 feet of water, or where they have been covered and kept in the dark. It is therefore necessary to bear this in mind when constructing service reservoirs.

In order to confine the operation of filtering within the smallest possible limits, the filter may be so contrived on the premises as to deal only with the water to be used for drinking, washing, brewing, &c., while for stables, cattle, gardens, house washing, closets, flushing sewers, and fire service, the water may be left unfiltered. It will be necessary to have the tank or reservoir occasionally cleaned out, and it should therefore be constructed in two parts, so that one part can be cleansed while the other is full, and a continuous supply be thus ensured. Reservoirs or tanks may be left uncovered, provided they are of sufficient depth, when they are in the open country and away from smoke, dust, leaves and other polluting sources; but if near buildings they should be covered to keep these matters out, as water is very quickly impregnated by them, especially when shallow.

There are probably few towns supplied with such good water as London; all that is taken from the Thames and River Lea being filtered, and we know that in both cases the sources are chalk and the strata both above and below that formation.

The following is a summary of the returns as to the composition and quality of the Metropolitan waters in December 1873, made by Dr. Letheby to the Society of Medical Officers of Health:—

Names of Water Companies.	Total Solid Matter per Gallon.	Oxygen required by Organic Matter, &c.	Nitrogen.		Hardness.	
			As Nitrates, &c.	As Ammonia.	Before Boiling.	After Boiling.
THAMES WATER COMPANIES.	Grains.	Grains.	Grains.	Grains.	Degrees.	Degrees.
Grand Junction	20·93	0·047	0·131	0·003	16·0	3·6
West Middlesex	20·43	0·025	0·129	0·001	15·8	3·6
Southwark and Vauxhall	20·70	0·041	0·134	0·002	15·9	3·6
Chelsea	20·67	0·028	0·148	0·002	15·9	3·6
Lambeth	20·93	0·037	0·115	0·003	16·0	3·6
OTHER COMPANIES.						
Kent	28.73	0·015	0·257	0·000	21·8	5·7
New River	20·33	0·022	0·147	0·000	15·6	3·5
East London	20·87	0·071	0·167	0·002	16·0	3·6

As a rule, all the softest kinds of water are more injurious to and destroy iron more quickly than the harder water, but this is in a great measure prevented by Dr. Angus Smith's composition for application as a lining to iron pipes, tanks, &c.

Dr. Voelcker states that water which has been acted upon by lead is not so injurious as is generally supposed. The waters which act upon and dissolve lead are those which contain organic impurities, alkaline constituents such as carbonate of soda and potash, and those in which carbonic acid is present. Fortunately, however, the lead may be easily got rid of. A small piece of zinc in the water will destroy the injurious effects, because zinc is more readily attacked than lead; it will also be precipitated by the carbonic acid which will be absorbed by the water on exposure to the air. An ordinary filter will arrest the particles of lead.

From the Report of the Water Supply Commission it appears that moderately hard water, the hardness of which is due to the presence of carbonate of lime, when used for drinking purposes is not injurious to health. Persons, however, who are accustomed to soft water, might be disagreeably affected by changing it for hard water, and *vice versâ*, but those who are in the habit of using hard water of that quality are not injuriously affected by it. And again, although there is no evidence to show that water which is hard owing to the existence of sulphate of lime is absolutely injurious, water of that quality of hardness is objectionable. The evidence proves that for washing, soft water is far preferable to hard, and is also more economical.

The following Table gives analysis of water from some of the various strata. All these waters are actually in use. The table therefore may be useful to you as forming a standard with which analyses of water from similar sources may be compared. The results are expressed in parts in 100,000:—

Strata.	Locality.	Total solid Impurities.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates or Nitrites.	Total combined Nitrogen.	Chlorine.	Hardness.	
									Temporary.	Permanent.
			*	*	*					
Chalk.	New Wimbledon ...	33·38	·063	·038	·004	·047	·088	2·38	6·28	6·96
	Worthing new Well	32·44	·007	·000	·002	·420	·421	3·08	16·36	8·33
	Littlehampton ...	50·24	—	—	trace	·071	—	7·13	21·04	8·00
	Tring	28·60	·036	·010	·001	·094	·105	1·39	22·96	3·37
Oolite:—	Northampton ...	57·76	·168	·024	·003	·000	·026	5·153	8·64	1·69
	Bedford	72·46	·133	·021	·001	·034	·056	4·27	29·31	11·46
New Red Sandstone:—	Liverpool (av'ge. of 4 waters:—	28·14	·020	·028	·001	·481	·502	2·83	1·65	10·63
	Runcorn:	60·80	·118	·011	·000	·382	·394	7·00	8·10	17·24
	Warrington	24·34	·027	·002	·000	·310	·312	1·64	7·92	10·17
	Birkenhead	18·80	·041	·038	·000	·366	·404	3·40	0·15	9·71
Mountain Limestone:—	Giggleswick... ...	20·98	·011	·007	·000	·040	·047	0.98	10·88	5·50
Dolomite:—	Sunderland	44·18	·035	·030	·000	·416	·446	4·17	0·79	13·95
Coal:—	Accrington	33·42	·045	·017	·000	·012	·029	1·40	7·70	2·18
	Little Harewood ...	36·96	·117	·055	·002	·029	·086	1·29	9·20	1·16
Lakes:—	Westmoreland ...	4·80	·263	·056	·002	·006	·064	0·82	0·76	2·52
	Cumberland... ...	4·70	·170	·044	·003	·000	·046	1·09	0·20	1·52

---

* The numbers in these columns (which indicate the amount of putrescent organic matter) ought to be very small, and the presence of much chlorine (unless accounted for by the proximity of salt water or of salt-bearing rocks) indicates contamination with urine from cesspools, sewers, farm-yards, &c.

Quantity of Water.

The next branch of the subject which we have to consider, is the quantity of water which it may be necessary to provide for a mansion and all its belongings. The basis of this calculation is, that of the number of persons who compose the establishment, and are dependent upon and require an ample supply, and in addition a considerable allowance should be made for storing it, to meet contingencies, such as fire, the lessening or total failure of springs or streams in long droughts, and other causes at those particular periods, as in summer, when larger demands are made upon the supply than in other times of the year.

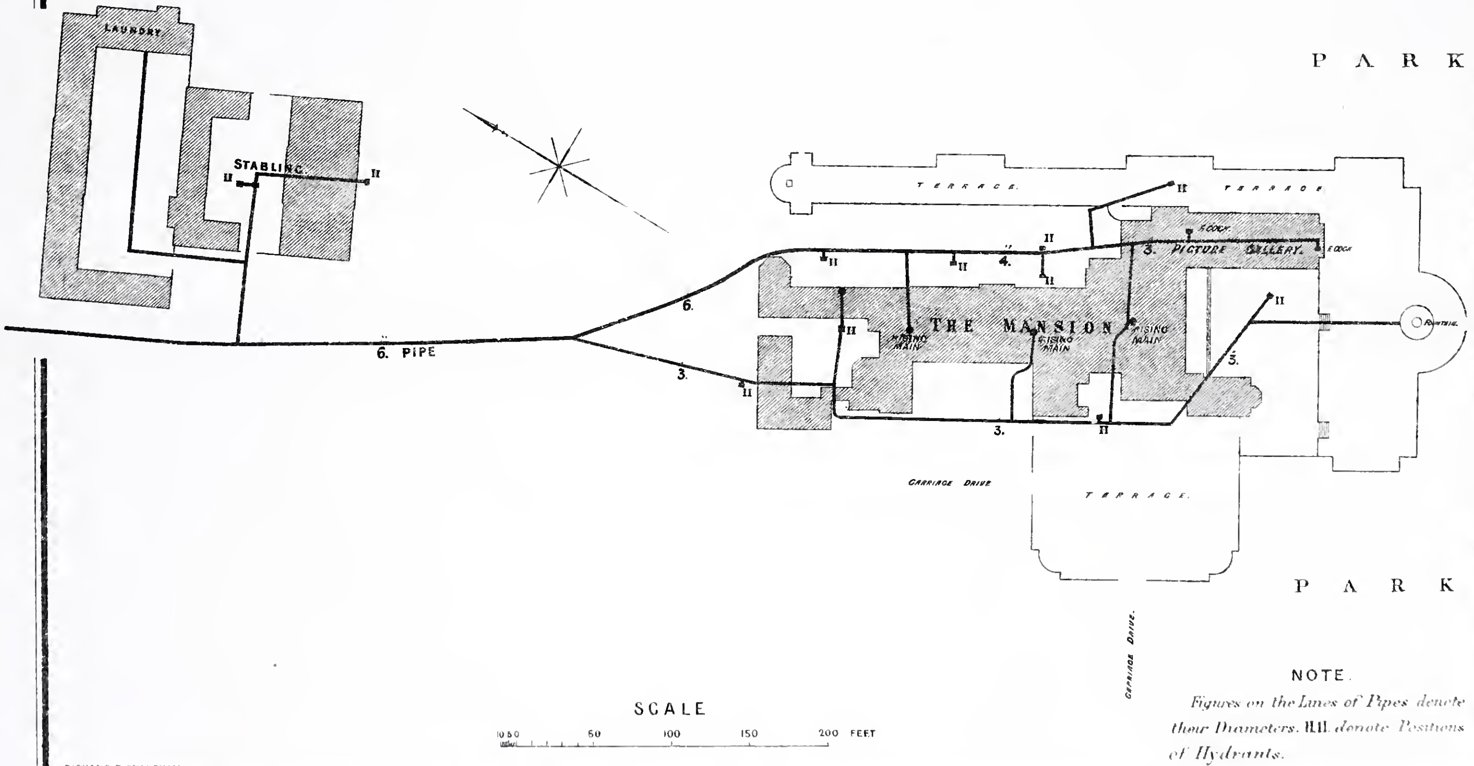
In an establishment such as that of a nobleman or gentleman in the country the personal requirements may not be more than ten gallons per head of residents per day; but for all other purposes, such as house washing, also for horses, carriages, cattle, watering pleasure and vegetable gardens and roadways, fountains, cooking, brewing, clothes washing and several other purposes, ten additional gallons should be provided, making twenty gallons per head as the probable consumption of the establishment, and in addition to this amount there should be provided a storage equal to three months' consumption in the case of fire and in the event of the supply failing in dry weather. It is not safe to depend upon pumping or other means of raising water, or supplying it by gravitation to check fire without a service reservoir, as much time is lost in getting the pumps to work, and the supply at the source at the time may not be sufficient. The ordinary nozzle of a branch or distributing hose will not discharge more than 50 gallons per minute.

In some situations where farms and villages on an estate are situated at great elevations, and where water is difficult to procure, or probably not of good quality—and again, in the case of fire, it may be necessary that the storage for the mansion should allow by a slight increase of its capacity to be extended to those localities, and it would be but reasonable that a small rent should be demanded. Another want sometimes arises, and that is the supply of ponds for cattle in the fields in summer. For this only about one inch pipe would be needed. It may also be found agreeable to form a skating pond, which requires a very small quantity of water to keep it supplied.

Modes of Supply.

The modes of supplying water are by pumping either by steam power, water wheels, turbines, horse power, or by hydraulic rams, from wells or from reservoirs, rivers, or streams, at a lower level than the building to be supplied, and thus raising it so as to command the highest roof of a mansion and its surrounding buildings. In certain situations it is possible to gather and collect water in a tank or reservoir at such an elevation, that it may by its own gravity be conducted to the premises by iron pipes at constant pressure, so that all parts of the buildings, gardens, &c., may be supplied without the expense of pumping or lifting. The latter mode of supplying water is far preferable to all others. The next best is that of pumping either by steam, horse, or water power, up to a reservoir constructed on elevated land so as to command the mansion. Where the mansion and buildings are situated on high land, and no higher can be procured within a reasonable distance, a tower should be erected which may be made more or less ornamental, according to the character of the architecture of the mansion. Upon this a tank should be placed; but a tank of this description is always objectionable and must be limited in size owing to the great expense of construction and the difficulty of combining a pleasing appearance with a large capacity. Where there is high ground a reservoir may be adopted which may be constructed of brickwork or concrete and puddled. The increased cost to attain size is not the same in proportion as in the case of a tower. Even the length of piping from the source of supply to the reservoir and thence to the buildings should not weigh against the adoption of a reservoir built on high ground; at all events, it is beyond all question that as large a storage as it is possible to obtain high above the buildings, as in towns, is absolutely indispensable *both for domestic purposes* and protection from fire.

SOMERLEY. PLAN SHEWING THE WATER SUPPLY TO MANSION.



NOTE.
Figures on the Lines of Pipes denote their Diameters. H.H. denote Positions of Hydrants.

RICHARD B. GRANTHAM
22 WHITEHALL PLACE S.W.

Photo-Lithog.d for the R.I.B.A. by C.F. Kell, London.

Details of Fire Service.

I now wish to call your attention to a short description of a case of water supply which has been successfully carried out and which affords an illustration of what is necessary in a fire service. I have selected this case for description, because I think it typical of a mode of water supply to a mansion. It includes all the details of a case of supply by simple gravitation, with the addition of a pumping engine worked in connection with a saw mill, which is used for estate purposes. You have therefore the pump applied in the most economical form, and I venture to think that there are few estates where, if pumping the supply is an absolute necessity, the engine might not be made use of, either, as in this case, in connection with a saw mill, or at the home farm for working farm machinery. Whether, however, you apply water power or steam power, the details of supply remain much the same, having regard of course to varying circumstances. The case referred to is one which I have lately completed at Somerley, the seat of the Earl of Normanton, in Hampshire. It was at first proposed to erect a water wheel on the River Avon and to pump the water from that river to cisterns on the top of the house. This was afterwards abandoned in favour of pumping by steam from a stream on the north side of the house, the engine being further employed in sawing the timber of the estate, for repairs, &c. By attaching a homestead the engine could have been made to work the chaff cutting, thrashing, and other machines, when not engaged in pumping. This latter plan was adopted, but the homestead was not built. Some springs of excellent water, soft, clear, and free from pollution, were found issuing from the Bagshot sand and gravel, with occasional beds of clay, which compose the hills running north and south through the estate, and bordering the valley of the Avon. These contain a large body of water, forming, as it were, a natural reservoir. Their waters are collected in a service tank at a high level, from whence the water descends to a pumping well near the engine. This well was constructed near the stream before alluded to, in which a dam was placed to keep up the water, so that if necessary the stream water could be let into the well. The plan of part of the estate shows the positions of the mansion, engine reservoir, service tank, filter and lines of pipes. The stream water is of good quality, but rising on a moor in peat soil is discolored, and contains organic matter. The engine is of 12-horse power, and drives a large circular saw for cutting up native timber, which at times absorbs all its power. The water is forced up a rising main of 3 inches diameter for 1,460 yards, to where it meets the 6 inch main, by which it is continued to a reservoir on Somerley Heath, a distance of 2,200 yards, altogether 3,660 yards, upwards of 2 miles at an elevation above the engine of 100 feet. The reservoir is built of concrete, on the highest ground that could be found within a reasonable distance of the mansion, is open, in a clear atmosphere, so that the water is well aerated and kept fresh. It is 10 feet deep, 60 feet square at the water line, and contains 150,000 gallons. The engine generally pumps for 2½ to 4 hours a day (according to the consumption at the mansion) at the rate of 50 gallons per minute, which is much more than is required. The height of the water in the reservoir is indicated in the engine house by means of Bourdon's Pressure Guage, so that the engineman can at all times see whether the water is falling and when it is necessary that he should pump. From the reservoir to the mansion the distance is nearly one mile and a half, and the water is conveyed to it by a 6 inch main. The house has recently been raised one storey higher and enlarged, with a conservatory, extensive terraces, with fountains, carriage drives, and additional garden space, and all laid out with very great taste and elegance. The bottom of the reservoir is about seven feet above the tops of the roofs, or the surface of the water is 17 feet above the roofs. The whole of the pipes are of cast iron, well jointed and lined with Dr. Angus Smith's composition, which prevents the corrosion of iron by this kind of water.

The flower and kitchen gardens, the stabling and laundries, are all supplied. There are stop cocks to shut the water off if necessary for repairs or additions to the pipes, taps, &c. I am indebted to

Mr. J. McVicar Anderson for the block plan of the mansion, terraces, and stables, as shown by the drawing attached to the paper, and upon which I have laid down the lines of the pipes and positions of the hydrants round the house and to the stabling, and also the positions of the rising mains to the floors above. The sizes of the various pipes are also given. Outside the mansion the positions of the hydrants are all indicated upon the walls near or opposite to them. Stand cocks can be fastened in the hydrants, and to them the lengths of hose are screwed on. The pressure in the pipes is sufficient to throw jets of water from these hydrants over and upon the roof of the mansion and gallery. Within the house the pipes are laid along passages, corridors, and under the drawing room and saloon to the interior, under the picture gallery, at both ends of which are hydrants immediately under trap doors in the floor where hose, wrenches, and spanners are ready at the shortest notice to turn the water on, and it can by these means be directed to every part of the gallery. The water is also raised by upright pipes to every floor of the house, and fire cocks and hose are placed in recesses in the walls readily accessible and at such intervals that two lengths of hose from different stand cocks can always reach and discharge into every room in the house. There are also large cisterns in the roof for supplying the closets and the warm water apparatus, &c. all over the house. The working pressure on the mains at the house in this case is about 28 lbs. per square inch, which is sufficient to cause a discharge of about 50 gallons per minute through the nozzle of the hose if worked only from the engine but if worked from the reservoir several jets could be worked at the same time, each delivering an equal quantity. The cost of the whole service of pipes and the reservoir, but exclusive of the engine, which exerts about 4 horse power for pumping, was about £2,000, and the annual cost does not exceed £40. The whole work was executed by Messrs. Eastons and Anderson, of Erith. The amount of property which is protected is very considerable, comprising the building and furniture, and the gallery which contains a very valuable collection of paintings, statuary, &c.

DESTRUCTION BY FIRE, AND INSTANCES OF PREVENTION.

It is unnecessary to enumerate the cases which have so frequently occurred of total or partial destruction of mansions by fire, as they are of public notoriety, and most persons are generally acquainted with them, nor would it be possible to give the details of the causes, &c., of these calamities; but it may be interesting to mention a few among those mansions which have actually been preserved from threatened destruction by the possession of a fire service.

EARL DARTMOUTH'S, Patshall, a covered reservoir pumped by rams.
LORD WHARNCLIFFE'S, Wortley Hall, natural gravitation from reservoir.
EARL BROWNLOW'S, Ashridge, pumped by steam into reservoir.
EARL OF ELLESMERE'S, Worsley, gravitation from reservoir.
BERESFORD HOPE, Esq., Bedgebury, pumped by rams into reservoir.
DUKE OF NORTHUMBERLAND, Albury Park, pumped by turbine into reservoir.

There are numerous mansions, in addition to the above, in various parts of the kingdom, which are provided with fire services, amongst them being those of Earl Harrowby, Sandon; Duke of Marlborough, Blenheim; Earl of Carlisle, Naworth Castle; Marquis of Camden, Bagham; Her Majesty, Osborne; Prince Christian, Cumberland Lodge; Lord Skelmersdale; Earl of Leicester, Holkham; Earl Dudley, Witley; Earl of Carlisle, Castle Howard; Marquis of Northampton, Castle Ashby, Sir Wm. Marriott Down House; Sir Wm. Bulkeley, Beaumaris; and many others.

Insurance is resorted to to repay losses of premises, furniture, &c.; but it is, of course, totally inadequate to repair the loss of works of art, rare books, antiquities, &c., which are often of great historical interest and national value. Where such are protected by an effective fire service, a portion of the annual cost of water supply may be fairly regarded as an insurance premium. Any house, of whatever size, in almost every town, may be provided with a fire service, by attaching one or more fire cocks to the high service main, with proper hose, as already prescribed, kept in a convenient and accessible place in and about the house, at a comparatively small expense.

Necessity for practising a Fire Service.

I may conclude by remarking, that unless proper attention is paid to the sources of supply being protected from pollution, the reservoirs, pipes, taps, pumps, &c., kept in working order, all the care expended in designing and carrying out the works may be abortive, and they may become a source of loss and disappointment, and even of positive annoyance and injury. Careful supervision and frequent exercise of all parts of a fire service are essential, and it should be practised say once a month, and a mechanic, such as a carpenter or smith, should be trained to work the system, making himself acquainted with all its details, and with the premises, so that he might be able to superintend the service, make slight repairs, &c. Such a person could probably also attend to the drainage and such like matters of the whole of the premises. Most serious consequences have resulted from the want of a practised organization, even with every appliance at hand, and experience proves what confusion and alarm prevail on the sudden outbreak of fire, when all concerned are generally tumbling one over the other, forgetful of everything but self preservation. This is quite natural, and can only be counteracted by the confidence which will result from the existence of an effective and well ordered fire service, under the control of a person capable of directing its use to the best advantage.

The President,—Will any gentleman favour us with any remarks upon this very interesting paper?

Mr. Charles Barry, Fellow,—I feel indebted to Mr. Grantham for bringing this subject under our notice, because it is one which has necessarily attracted the attention of most of us at different times, and the particular instance before us is interesting in many respects. There are a few questions, however, which seem to me not to have been fully considered, and on which I should be glad to receive a little more information. The first is as to the number of gallons of water per day which Mr. Grantham stated to be required for the personal use of each inmate of an ordinary house, which he placed at ten gallons per day for each, to which he added a further ten gallons per head for various domestic uses. I would beg to ask on what basis that is founded, and whether it has relation at all to the experience of the different water companies, and to their supply of mansions under their various systems. The other point which occurs to me is as to the cost of such a system as that described, when applied to some of the houses named by Mr. Grantham. He states the cost in the case before us to have been £2000. I would ask whether that amount includes the cost of the reservoir, and if so, what is the character of the reservoir, and if covered or uncovered. I was surprised to hear that estimate. It is very much lower than I should have supposed it would have been, considering the work which Mr. Grantham has described. I presume the cost would depend in some degree upon the character of the soil for the reservoir, and the depth of the pipes below the surface to protect them from the frost. I would also ask whether any difficulty was found to arise from the imprisonment of air in the pipes between the house and the reservoir, as I have known of that difficulty sometimes arising, and I should like to know whether it arose in this case. At the proper time I shall be happy to move a vote of thanks to Mr. Grantham for his paper.

The PRESIDENT.—I would add to the inquiries made, one with respect to the different kinds of impurities of water—Which is the more, and which is the less noxious?

Mr. T. MORRIS, Associate,—It is understood that covered reservoirs are preferable to open ones. I think that hardly so much stress has been laid upon the filtration of water as it deserves; and it has not been stated whether it would be preferably carried on near the source of supply or at the place of consumption. One other little point occurs to me as to the motive power in supplying reservoirs with water, which has perhaps been overlooked—that is the power of the windmill, which I think might be made a useful agent, in combination with an object of picturesque character, in raising water for the supply of a large house to the required elevation. The hydraulic ram has not been much touched upon, but where there is a large source, and an abundance—even a superfluity of water passing to the ram, it seems to me that such a means for the supply of water to mansions might be employed with great advantage.

Mr. C. FOWLER, Fellow,—There is one other point on which Mr. Grantham can give further information. We may assume that the main pipes are of cast-iron. We should like to know the extent to which cast-iron pipes are carried throughout the mansion; and whether they are all cast-iron, or whether at any other point he adopts other means of directing the water.

Mr. R. B. GRANTHAM,—In answer to Mr. Barry as to the basis on which twenty gallons per head has been calculated, it is that of towns' supplies generally. Twenty-five gallons to every person is quite sufficient; that is, taking all ages and for all purposes of the town. But I say in this case the supply is twenty gallons per head of residents—ten gallons for domestic purposes immediately, and ten gallons for horses, gardens, etc., and a reserve for fire. Now in towns, taking the large quantity there, twenty-five gallons are assumed to include fire service in a general way. Of course, in large manufacturing districts they want a hundred gallons per head per day, and that must be provided at any charge. With respect to the cost of these works I may state that the reservoir is included in the £2000. It is formed of concrete, executed partly in the ground and partly raised above it. The soil in which it is built is gravel and sand and peat. It is on heath land, just on the borders of Dorsetshire. As to the material of which the pipes are constructed, I should fancy any practical man could judge, with a pressure of 28 lbs. to the inch at the mansion the pipes must be all cast-iron, and they are the same all over the house.

At the top of the house there would be no pressure, but there is great pressure at the lower part, and nothing but strong cast-iron, calculated according to the pressure it has to bear, would sustain it. The soil in which the pipes are laid is a gravelly and sandy soil, with peat in some places. One gentleman asked why the route is so circuitous. The reply is that part of the pipes was laid below ground and supplied the kitchen gardens and the remainder was carried over very high ground. With regard to the difference of diameter of the pipes it was necessary to have the 6-inch pipes where they are laid between the reservoir and the mansion, because the elevation of the reservoir is not much above the highest points of the roofs; therefore it was necessary, in order to make the flow more rapid in case of fire, to have the pipes larger than would otherwise be the case. The 3-inch pipe would have served throughout if the house were lower, or if the reservoir were higher above the house. The depth below the surfaces at which the pipes are laid is from two feet to three feet, which in this country is quite sufficient; eighteen inches, even, being sufficient depth to keep them from frost. I should state with regard to the course in which the pipes are laid, that there are some cottages and gardens supplied by branches from the main pipe, and the water is capable of being sent over the whole estate.

There are two tanks at the top of the house, and these are for the purpose of supplying the water closets, and the warm water supply which circulates about the house, but they cannot be touched by frost. It would not do to leave anything to the chance of there being no water, whilst the bursting of a water pipe would cause great damage and destruction of property. If anything went wrong in the drawing room or saloon it would be most serious; but we have taken every precaution against that.

The **President**,—Perhaps you may be able to add a note to the paper with respect to the comparatively objectionable character of the different mineral and chemical substances in water to which you have referred.

Mr. **Grantham** undertook to insert a note with the information required.—So far this water issues from springs of great purity. We have not found in it those impurities mentioned in the tables at all. The water is as pure as possible, flowing as it does from the side of the sand hill, and every care is taken that pollution, such as that from cattle and farm buildings, should not go near the springs. I have answered the question as to the different sizes of the delivery pipe up to the reservoir. It may appear to be a round-about way to send the water. [Mr. Grantham explained the course of the pipes on the plan.]

Mr. **Barry**,—Are we to understand that the same pipe takes the water from the engine to the reservoir, and then returns it from the reservoir to the house?

Mr. **Grantham**,—Yes, and the engine is working at the same time the reservoir is working. We force the water against the current coming down. With regard to filtration, in a case of this sort there is little or no necessity for filtration, the water itself is so pure. No organic matters can get into it. If we took water from that brook [pointing] which comes down from another part of the hill, there, in fact, filters are built at this moment, in case anything happened that the spring we take the water from should fail: those filters would then be used for the stream water, which is of a brown colour like that of Manchester, where the water is coloured from flowing through a peaty country. With regard to the use of windmills for pumping, I am afraid you cannot rely upon that power for all purposes. In this case it would be just in the very place where it could not get the wind. If it were on the top of the hill something might be said to it; but this is quite in the hollow of the valley, and it would be an impossible place to work a windmill; and there is no water where the wind would be—that is, on high ground. And under any circumstances I should never advocate windmills in connection with water supply, nor for effective drainage or pumping should I ever recommend their employment. As to hydraulic rams I may state that was the system adopted by the late Lord Normanton, and the water was pumped up into a tower. The tank held only 7000 gallons, and it took nearly a fortnight to fill it. The late Lord was always very anxious about it, more especially with regard to the picture gallery, which was totally unprotected from fire with the exception of this 7000 gallons to save anything. I do not think rams would be sufficient for the purpose unless you have an enormous reservoir and the rams are always at work. You cannot always depend upon them: they are hazardous. I believe they are used for supplying reservoirs, but where there are other purposes for which the engine can be used, the engine does not cost above 30s. a week, going all day long, and the total cost is only £40 a year, in this case, for an endless supply of water for the whole house.

Mr. **Barry**,—I have now the pleasure of proposing a vote of thanks to Mr. Grantham for his interesting Paper.

Mr. **Jennings**, Fellow,—I beg to second the motion.

The resolution was unanimously passed.

ON THE INTRODUCTION AND USE OF THE STEAM JET,

FOR CLEANING THE STONE OF HANOVER CHURCH REGENT STREET.

By EDWARD C. ROBINS, Fellow.

IN obedience to the suggestion of the Council I have much pleasure in making the present communication. The introduction of the use of the steam jet to the metropolis for cleaning the façades of our public buildings has never been entirely absent from my mind and purpose since I witnessed it in operation at Paris some years since. The opportunity has alone been wanting, and until the peculiar circumstances connected with the restoration of Hanover Church arrived, I did not feel myself in a position to introduce it to London, for the first time, with economy and efficiency combined. Fifty years accumulation of soot had so deeply blackened the whole façade of this church (which, being of Bath stone, did not whiten with the weather like Portland, but became entirely shrouded in an impenetrable veil of intense blackness), that all play of light and shade was absorbed and a dark and forbidding aspect characterized it at all times, only the more observable by contrast with its bright and lively surrounding, being situated close to Oxford Circus. On the completion of the works, which cost £280., (exclusive of the mason's work for the insertion of new stone in place of that too far decayed) I addressed a letter to our Committee for the Conservation of Ancient Monuments, from which I extract the following brief statement; after the reading of which I shall be glad to reply to any questions.

"In the year 1867, I was walking near the Champs Elysée, in Paris, when my attention was arrested by what was to me a novel process for cleaning down the façade of one of the public edifices.

"Upon a suspended scaffold, commonly used in France, a workman, whose head and hands were sheathed in a protective covering, was holding the nozzle of a pipe, connected by tubing with a steam generator situated on the ground below. After watching the process, and observing the facility with which the sculpture and carving were effectually cleaned by the steam jet directed by the workman, and aided by the simple operation of brushing, I made a note of the circumstance for future use. (*See Illustration.*)

"Last year I was requested by the Vicar and Churchwardens of Hanover Church to undertake the renovation of the building. Acting upon my report as to the necessity of restoring the external stonework, in the first instance, I was requested to do something to improve the gloomy appearance of the façade, which had become encrusted with a thick mass of black smoke. A strong party in the parish were most anxious that I should remove the portico altogether. I need not say that my respect for our first President's (the late Professor Cockerell) design, caused me strenuously to oppose such an act of vandalism, in which I was ably supported by our Hon. Secretary for Foreign Correspondence, who kindly consented to act on the Restoration Committee, but I pledged myself to clean down the front in such a way that the beauty of the details should become visible by the removal of the smoke and the resuscitation of the natural colour of the stone.

"To accomplish this end without injury to the building by any tooling of the surface, I called to mind the process I had seen in operation in Paris, and straightway went thither, taking with me my mason, Mr. Whitehead. For several days I could find no clue to the process, which had not been seen in Paris since the war. At length I was directed to the patentee, Mons. Nivert, from whom I obtained

ILLUSTRATION OF THE

APPARATUS FOR CLEANING THE EXTERIOR OF BUILDINGS,

Referred to in Mr. Robins' Paper.

FIG. 1.

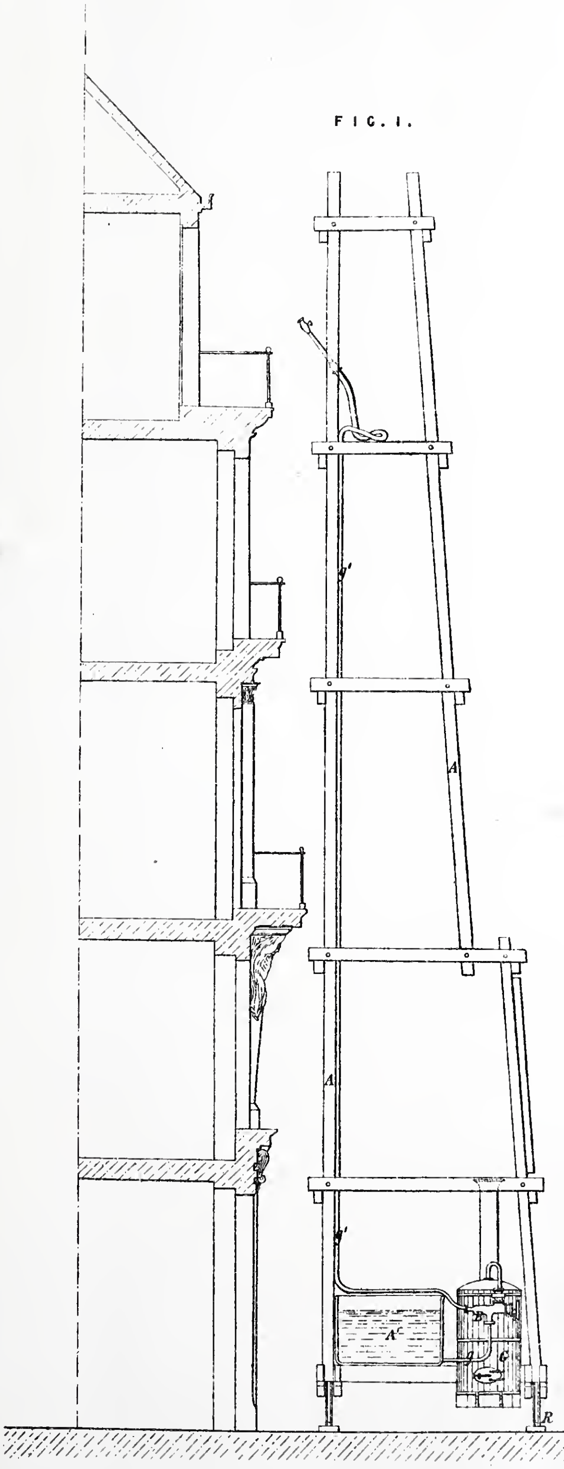


FIG. 3.

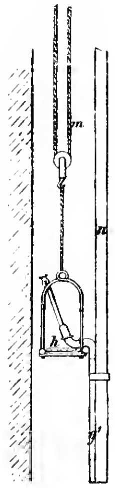


FIG. 2.

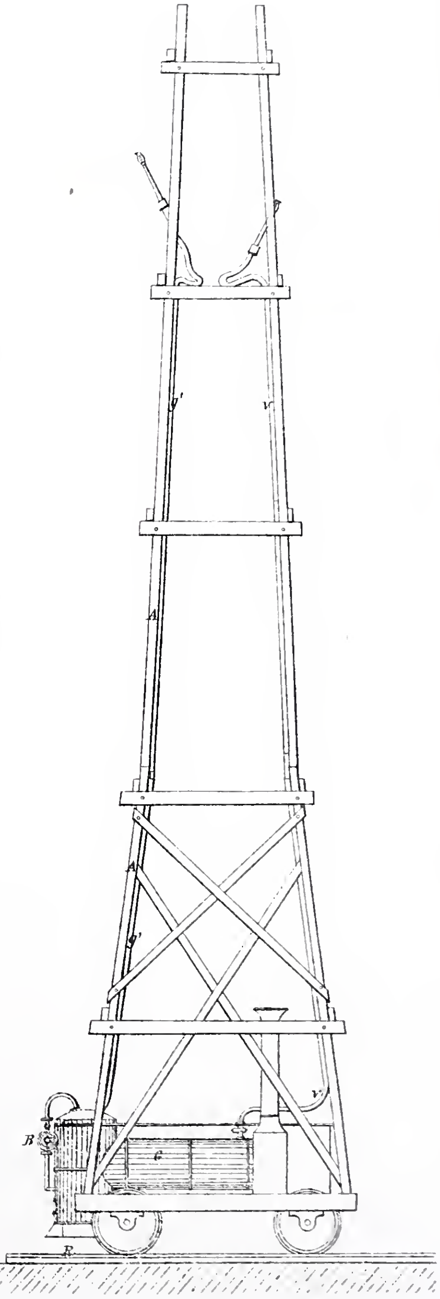


Photo-Lithog.d for the R.I.B.A. by C.F. Kell London

a prospectus, with a list of the buildings operated upon at the time of its publication. I learnt also that though patented in France and England, financial difficulties had stopped its continued use.

" Arriving in London, I obtained the specification at the Patent Office, and was informed that the letters patent granted in 1866 had expired in 1869, and had not since been renewed. It was open to me, therefore, to employ the process on my own responsibility, which I at once did, obtaining from Mr. Sykes, of Bankside, the necessary apparatus, in the shape of a steam generating boiler, fitted with tubes and nozzles for the supply of steam, and an injector for raising a column of water, with which Mons. Nivett mixed chemicals; a constant supply of water from the main kept the feed-cistern at one level.

" The result of this experiment has been most successful, in the opinion of the competent architects who have inspected the process in action, while the appearance of the building, which is faced with Bath-stone, will speak for itself.

" There has been no tooling or dragging of the surface of the stone-work, except where new stone has been inserted in the place of stones absolutely decayed. This new stone-work has received three coats of Ransome's preserving solution. The old stone facing, after being played upon by the steam jet, and rubbed down with hair and wire brushes, and left quite clean, was so little affected by the process that it was found impracticable to use Ransome's solution upon it, since it remained on the surface, and had the appearance of whitewash, the weathered face being insufficiently porous to receive the solution—an incontestible evidence, that with a pressure of 56lbs. of wet steam, the surface of the stone has not been damaged.

" At first strong lyes were used in the form of a wash previous to using the jet, but it was soon discontinued, the steam jet being found equally efficacious without any chemical aids.

" Care must be taken to prevent accidents from the pressure of the steam in piping, junctions, and nozzles. But in this and other practical details, the experience gained by Mr. Whitehead will be found eminently useful to any architect desiring to repeat the process.

" I have only to add that I have thought the result of this experiment sufficiently important to call the attention of the committee, and of the profession generally, not only to the means it offers for cleansing Metropolitan buildings, but for the conservation of ancient monuments.

" Paint and whitewash may alike be removed by judicious operation. And the interiors of our old country churches, so often irrevocably injured by too zealous restorers, may by this means be rid of the preserving whitewash without injury to the details of either stone, wood, or metal work—superseding any necessity for tooling or dragging the surface of the stone, which has ruined so many examples throughout the country, rendering them comparatively valueless for the purposes of study."

Mr. Edward Hall, Visitor,—If no one rises I should like to remark that I consider the slow progress of architecture as mainly resulting from the dirty state of the buildings and atmosphere of our towns. I believe there will not be a sufficient appreciation of our art by the public, so long as what may be called the life-time of the decorative portion of each building is shortened by the gradual but speedy obliteration of ornamental details which become encrusted with soot and dirt as in London. Therefore I think that an architect who has introduced a process of this kind is deserving of the hearty thanks of the whole profession. I am much pleased at the perfect success of Mr. Robins's application of the steam-jet to the exterior of this celebrated building. I believe that the sand-blast was at one time suggested for the cleansing. The effect of that process would have been not the preservation but the destruction of the details and architectural character. It would be desirable if some information could be given as to the precise process which was adopted in this particular building, with the object of preservation of the stone. Perhaps Mr. Cockerell, who is present, can afford that. I have always understood that the whole of the external stonework of Hanover Chapel received a coating of some kind—I believe oil—and that this was the cause of the dirty or black appearance of the building previous to the application of the cleansing process. I am sure that if Mr. Robins's process be used extensively for our buildings, one result of the successful application would be a better appreciation of the work of the architect, and a great advance in the public taste for some time to come.

Mr. F. P. COCKERELL, Hon. Secretary,—I am able to state that the stone work of this church was coated with oil; how many coats I cannot say. My father frequently used oil where soft stone was employed, especially for carving. If it is done by a person who is careful in the application of it, so that no more oil is used than the stone will thoroughly absorb, the appearance of the surface is not affected in any way. It would appear, however, that in this case the requisite skill was not used, because there were places where, after it had been softened by the action of the steam jet, the surface substance could be scraped off with the finger nail, and I have no doubt that was owing to an excessive quantity of oil. You could see it in the colour of the stone. In places it was quite of an orange colour.

Mr. T. MORRIS,—The Carlton Club-house was coated with oil in a recent renovation by Sir Sidney Smirke. My own notion at the time was that sulphur was used, because there was a process of cleaning stone with sulphur and oil, which was considered to have a preservative effect; and the colour indicated that sulphur was employed. But I was told it was simply a coating of raw linseed oil. It produced a striking yellow effect when first applied, but it very soon after toned down.

Mr. E. C. ROBINS, Fellow.—The towers of the church were not coated with oil, and were much decayed. You could well see the difference between the portions that were coated and those which were not. I think Mr. Cockerell told me he recollected that the towers were not coated; but the preservative character of the simple oil process, was proved by the sharpness of the arrises which were most coated with soot and dirt. I think there can be no question as to the value of the oil treatment in this case, and I understand that Mr. Street is now using it at York. With respect to the Carlton Club-house, I cannot tell you what was done there.

Mr. COCKERELL,—I beg to propose a vote of thanks to Mr. Robins for his interesting communication. I would just say that although I think oil is a very useful application, it must be used with great care and judgment to produce a good effect. As to the "steam jet," I have no doubt it will prove of good service in restoring ancient and modern buildings.

Mr. BARRY,—I beg to second the proposition, and I think we are especially indebted to Mr. Robins, for the bold and manly stand he made against the mutilation of the church by the proposed removal of the portico.

Mr. COCKERELL, Fellow,—We have to thank our President to some extent for the preservation of the portico, inasmuch as he was referred to by the Committee, and I need not tell you what his answer was.

The PRESIDENT,—I have great pleasure in conveying to Mr. Robins, the sincere thanks of the meeting for his communication. It strikes me as being of extreme importance, because, although sometimes we may think dirt picturesque, there is no doubt that soot and dirt are great elements of decay in towns; and to find a process like this, which, without abrading the surface at all, or even removing the coating given for preservation fifty years ago, will remove all dirt from the face of the stone, is of the greatest possible benefit. I think the great object is to have this machine so ready to hand that architects may enter readily into arrangements for the cleaning of a building. The late Professor Cockerell was, I believe, impressed with the idea that the removal of dirt was a great means of preserving of a stone building, from observing the good condition of the stone of the Church of

St. Peter le Poor, in Broad-street, in the city, and finding that its preservation was owing to the fact of the parish authorities having for many years caused the parish fire engine to be practised upon it, and from observing this, I have heard that he applied the same process at the Bank of England.

Mr. Cockerell,—My father did a great deal in the way of cleaning the stone-work inside, but as to the outside I cannot say.

The President,—This paper has also tended to prove the benefit of the application of oil to a stone building. We have found from it the very valuable fact that the effects of oil are more durable than were supposed. I was a member of the committee appointed to inquire into the different processes for the preservation of the stone work of the Houses of Parliament, and I recollect it was stated boldly and decidedly by scientific men, that no process in which oil was a principal ingredient would last above ten years. Here we have an instance of its duration for fifty years; so that that was evidently a mistake. I may mention that oil was used thirty or thirty-five years ago for coating the new tower on the west front of Canterbury Cathedral, and the effects of it are still visible.

The following Paper was then read :—

ON DELONG AND CO.'S PATENT STEAM-SAWN METAL WORK,

AS APPLIED TO ARCHITECTURAL DECORATION.

By C. H. Cooke, Fellow.

I am desirous of drawing the attention of the members of this Institute to a new mode or operation of metal working recently perfected in Paris, and applicable to iron, brass, and zinc, and this, without any attempt to imitate wrought or cast iron, combines the advantages of both, and expresses itself simply and plainly as " cut work."

The cutting of these metals is effected by a steam saw, the hardness and make of the saw being in reality the secret of the whole work, and, as you will see by the various specimens now exhibited, it offers facilities which could be obtained by no other means for the conception and working out of the most intricate and delicate designs. The zinc work, it is believed, will stand in this country, as it has in Paris, the effect of the weather, without painting.

This method of cutting through hard metals has been brought to great completeness. M. Delong & Co. inform me they can now cut brass and copper three inches thick and wrought iron one inch thick. The face of the work can be chased or engraved as desired, and in reply to a letter from the agents appointed for England (Messrs. Morgan, Allsopp & Co.), Delong & Co. state that after the pattern required has been cut by the saw it can be heated, and the twist at the ends or points, so frequent in wrought work, can be given, and certain portions of the ornamental work raised or depressed as desired; this, with the engraved work shown in the monogram, forms a combination in metal working hitherto unknown.

Having been the first, I believe, to use this new kind of work in London, I have taken considerable interest in its development. Several of the panels now exhibited have been made from my designs for different works in hand, and can bear testimony to the promptness and accuracy with which they have been executed from the full size drawings which I sent to Paris. The cost of this work is moderate, being *more* than a *third* less than wrought iron as usually prepared. I believe that this mode of working in metals offers great facilities in the field of architectural design.

PRINTED TIN-FOIL DECORATION.

I have now to call your attention to another French patent, introduced by a different firm, viz., the printing on tin foil imitation of woods or marbles, applicable to wall decoration, woodwork, houses, and furniture, which will be found, on examination, to possess many advantages.

Some will, I know, object to it as a sham; but we must have some shams, and for my part I look upon this as a very good and useful invention, especially as you can put this work upon *damp walls* and decorate the surface at the same time; besides which it offers great facilities for decoration in places where it is difficult to obtain skilled labour. The ease and speed with which it can be used will be specially valuable either in new buildings or temporary erections, and be a great boon, I believe, to our colonists. For halls and staircases it certainly will be much more effective and serviceable than paper-hanging as now used. From the extreme thinness of the material it is capable of enveloping the most delicate of mouldings, and the surface being *varnished* and then placed in a hot chamber and subjected to a heat of 120 degrees Fahr., is rendered permanent and durable.

This work can be obtained in rolls two and three feet wide and eighteen feet long.

The members having examined the specimens referred to, the meeting adjourned.

Royal Institute of British Architects.

At the Ordinary General Meeting, held on Monday, the 9th of February, 1874, the following Paper was read, HORACE JONES, Vice-President, in the Chair:—

ON THE CENTRAL DOME OF THE VIENNA EXHIBITION BUILDING,

By J. SCOTT RUSSELL, Esq., F.R.S.

TO the Institute of British Architects, I, who am no Architect, only an engineer, will not try to describe the architectural qualities of the great building which was provided at Vienna to welcome and shelter the scientific and artistic works of all nations in their world-wide exhibition which has just been closed. That building was the largest and possibly the most completely adapted to its aim that has yet been seen. I am of opinion that it possessed a high degree of fitness to the purpose prescribed for it, that it was a wise application of the peculiar resources, materials, and artificers, of the countries among which it was raised, and that its architecture reflects great honor on the architects of Vienna, and exhibits, in a remarkable manner, the specialties for which they are eminently distinguished. But I am not an architect, and, therefore, I hope that some member of your own Institute, who has visited Vienna and studied that remarkable building, will give you the benefit of describing it for your professional information, and will do the architects of Vienna that honor which only a professional judge can worthily bestow.

All that I as a professional engineer can venture to do, is to submit for your consideration those engineering principles and those mechanical expedients which I think may possibly be of service to your profession, in those great works which you and your successors will be called upon to undertake in the architecture of the future. Some of these principles are illustrated in the great building at Vienna, and some examples are there given of these inventive contrivances. These you may possibly think fit to approve in principle, and to adopt in your own future practice. My own special work is the great central iron dome.

So far I shall only be doing that which is strictly within my own province as a special professional engineer. Permit me, however, to say that I shall find it impossible not sometimes to express my feelings on matters of which I have no professional knowledge. I cannot help feeling admiration for a beautiful form, even when it has no mechanical merit, and I cannot help hating a hideous deformity, even when it is held up before us as a useful and meritorious work. There are good strong bridges, built by us engineers in the City of London, and huge railway stations, which we find it expedient to use, and both one and the other inflict sharp pain on me whenever they cross my sight, and remain on my mind as monuments of hideous deformity, which a people endowed with any slender sense of beauty ought never to have suffered to exist. These things, when I return from countries where the sense of the beautiful is the seventh sense, even of the uneducated mass, pain me much, and make me feel that if in some things we English appreciate the beautiful, we are totally wanting in a sense of the ugly! Hence, everywhere throughout London prevalent costly elaborate ugliness pains the eye and shocks the mind.

Now I do not blame architects for this—no engineer dare say so—for in the last fifty years, that is during my own professional lifetime, we engineers have created a greater number of ugly structures throughout all the cities of England than have ever been built by all the architects of the world, from the tower of Babel downwards. I do not, therefore, blame the architects of England for the ugliness of our great public works, and the monstrosities of our great cities. In our northern races, under our northern clouds, the sense of beauty is feeble, the sense of ugly is null, and if we are ever to know, love, and enjoy the beautiful in the works of Humanity all round about us, as we do love and enjoy the beautiful in the works of Divinity all round about us, it must be accomplished by a great national movement, undertaken by the educated and skilled part of the English people, to initiate, communicate, and spread throughout the working classes as well as the thinking classes, a belief that there are principles of beauty and of ugliness as fixed and sure as other laws of nature, and that these principles are exhibited every day to us by the lovely handiwork of God in trees and mountains, clouds and leaves, flowers, insects, shells, and stars; and that if we do not make all the works of man to resemble the works of God, in beauty of form, beauty of colour, beauty of proportion, and order, and play, and grouping, it is not because there is any impossibility of doing it, but merely because we have not been systematically educated to believe in the truth of beauty, and in the hatefulness of ugliness, and that we are not habitually trained from our youth up, to select the lovely and reject the ugly; that we have not governors and rulers, who hide ugliness as injurious to youth, and surround children in schools with all that is comely and graceful. These things are all wanting to our children, and so we grow up ignorant and prejudiced, insensible to ugliness, incapable of selecting the better from the worse, exposed to continual mistakes and disgust.

It is not my intention to go into matters of taste and beauty in architecture at all in this paper; but these remarks I could not omit, because they are the motives which induce me to venture to occupy this evening. It is my opinion that in matters of education, and in matters of profession, you the architects, and we the engineers, have need of one another, that we can greatly benefit each others work by sympathetic co-operation, that the public works of our country would be greatly improved if every public edifice were at once a model of architectural beauty, and an illustration of wise engineering construction.

What architects and engineers could do, and after my mind should do, is to come into cordial fraternal union in the creation of the great structures which are to form the architecture of the future from the beginning, to frame their designs together from the outset, and by a sympathetic cordial adoption of each other's views, to contribute each his part to a perfect whole. I admit frankly that all architects and all engineers cannot work well together, we are each apt to be obstinate and pig-headed in our own way, and to yield little or ungraciously to the other. But that is also the difficulty of common life. In all human work we are bound to co-operate, and the permanent pain of human life is imperfect half-hearted co-operation in the duty we must perform.

I propose to you, as the way to initiate this co-operation for the future, a close union of the two professions, in the education of the rising generation of young architects and engineers, so as to co-operate intelligently with each other in the works of both professions. We ought to know something of each other's professions, we ought to know, not that superficial little which might make us fancy we should meddle each in the other's part of the work; but we ought to have that deeper knowledge which teaches us that we know nothing, or, at least, not enough to warrant our touching the other's work. When we both know that much of what the other has to do, we shall be sure to let it alone. Let, therefore, the young engineer be well trained in architecture, and the architect well trained in engineering principles, and both will give each other valued aid, and both abstain from harmful interference.

I feel it my agreeable duty, in laying before this meeting of the architects of England a description of my own work in the great building at Vienna, to say how much benefit the whole of that building, and especially my portion of it, owes to your profession. You all remember the marvellous excellence of the original exhibition building in Hyde Park, and you all have recognised the distinguished merit of the Crystal Palace at Sydenham. As I am intimately acquainted with the story of these two buildings, which are the first types of a new nature of construction, I will venture to say that some of the ablest mechanical engineers of our time, and some of the ablest members of your Institute of architects, combined their highest efforts to give excellence to their common work, that the two professions co-operated cordially and harmoniously, and that they and we are all proud of the results.

In like manner I have to say for my own iron building at Vienna, that from the beginning to the end of the design I am deeply indebted to members of your profession for kindly help and cordial co-operation. When I made the first sketches of the Vienna building, the designs were all drawn for me by Mr. John Crace, the worthy son of a father who had long before acted a distinguished part in beautifying our two first Exhibition buildings. It was on his drawings that the design of my dome was first shewn at Vienna. Where these drawings of his do not correspond to the work as executed, it is because the rest of the buildings all round my dome were decided to be of a quite different style, and because as they were to form parts of one great whole, it became expedient that the same Vienna architects who designed the architecture of the surrounding portions, should design the architecture of that, so as to be in harmony as a whole. I have great pleasure in saying, that in Vienna I received as genial sympathy and as cordial co-operation, in the great work in which we were engaged, as I have always received in any matter of joint interest from members of this Institute. The architectural features and decorations of the dome, as now executed, are the work of M. Hasenauer, who at an early age has earned high distinction, and who inherits the traditions and talent of your profession from his distinguished father.

GENERAL DESCRIPTION OF THE CONIC DOME AT VIENNA.

The iron dome at Vienna is, I believe, the largest vaulted roof in the world. I think it covers nine times the ground of the dome of St. Paul's, eight times the area of the dome of St. Peter's, and seven times the area of the dome of St. Sophia, at Constantinople.

The dome is 360 feet in diameter, and 1,080 feet round. It stands on a ring of 30 columns, 36 feet apart all round the circumference. Within this ring of columns there is no support. The upper dome 100 feet diameter admits light by a series of windows 40 feet high and 10 feet wide, between 30 columns which carry the upper dome. I fancy the English architect will get the best feeling of the magnitude of this interior by going into St. Paul's Cathedral, looking up to the inner dome, and then imagining all the columns that carry the roof removed, and the upper dome left suspended in the air, but sustained by a lower dome resting only on the outer walls. The area covered, the height, and the dimensions, are sufficiently near to give the true impression according to my feelings, and I hope therefore, to yours.

Although the dome is carried on these 30 columns at intervals of 36 feet all round; and although the structure of the whole dome conforms to this symmetric division, two more columns are introduced by intercolumniation at the two entrances to the grand avenues, making in all 32 columns. These give beauty and do not destroy symmetry.

The slope of the cone is 30 degrees. The length of the slope on all sides is 200 feet. The roof is formed of 360 iron plates, tapering uniformly upwards from the circumference to the apex of the cone. They are rivetted like the plates of a ship. Each row of plates covers one degree of the circle, each bottom plate is one yard wide between the lines of rivets, and one metre wide over the lap.

The 30 columns which carry the cone stand round the circle at 12 degrees apart, except at the two intercolumniations. They are 36 feet from centre to centre, each carries an arch and an upper gallery all round the inside. These columns are 80 feet high.

The heights of the whole in round numbers are—columns 80 feet, cones 100 feet, windows 40 feet, lantern and crown 60 feet, say 280 feet from floor to crown, besides foundations of 12 to 20 feet.

This conic dome roof has no visible external wall, but is surrounded by a circular building, which consists of the great central nave of the longitudinal axis of the main building, carried circularwise round the cone, and forming, so to speak, a circular aisle or series of side chapels all round about it. The conic roof, therefore, as seen from the exterior, crowns the large low buildings by which it is surrounded, and seems merely to grow out of them, and to group them round it, into one whole, of which it is the centre. The whole outside decoration of both was meant to harmonise them, and not to give predominance to part. This circular ring, nave, or arcade, is 40 feet wide by 80 feet high, carried on a second ring of outer slender columns, and opening out into four enclosed courts, or gardens, by large semicircular windows and many doors. This arcade extends the circle of the central building to 440 feet diameter. It has the great convenience of forming a continuous communication through the entire length and breadth of the building, with all the main entrances, without disturbing the central area of the great dome; a quality of much practical convenience.

I defer to a later point the further description of the rest of the building, in order to enter at once on the theory and mechanical principles of the conic dome structure.

MECHANICAL PRINCIPLES OF CONIC DOME STRUCTURES.

I think I shall bring this subject most clearly before you, by saying at once that I confine my remarks to the peculiar principles which it seems to me should govern the proportions and indicate the structure of *very large* buildings, as distinguished from ordinary small ones.

The result of the investigations I have been occupied in making on this question, during some 30 years, is this—that a certain conic form developes the strength of that modern material called wrought iron, on a large scale of structure, so as to attain the maximum possible of strength, economy, and endurance. When I have satisfied you of the soundness of this conclusion—first by theory, secondly by experience—I hope that the result will be that you will adopt the conic dome, as one of those forms out of which you will develope combinations and proportions, satisfying to the mind of the spectator, sweet to the eye, as well as useful, economical, convenient, and durable.

The Nature of the Material.—The one characteristic of iron for permanent and powerful structures is that which is the criterion of good metal, viz:—that its tensile and compressive powers be equal, or that it should possess toughness as its characteristic. I have seen a select piece which had a tensile force one hundred tons on the square inch, which would snap by the slightest concussion. Cast iron with a tensile force of 5 tons only, may resist a crushing force of 20 tons. Materials for good iron construction may have as their measure, 20 tons tensile and 20 tons compressile force, and be at the same time in a high degree tough. That, and that only, I call good building iron. When I use the word iron, I mean that I don't care if its mercantile name be steel, iron, or toughened casting. It is easy to see that it is this equality in power to bear two opposite kinds of strain, that has made modern wrought iron plate so rapidly displace cast iron in large structures. When I want a long girder I find that the top breaks by one force, the bottom by the other, and if either is weaker, the excess of strength in the other is no good. True, an ingenious remedy is made in cast iron by making the tensile side of the beam fourfold in weight and size; that, however, means also fourfold cost. If, therefore, the material is not more than double the cost, the advantage of casting ceases, and modern wrought iron plate becomes better and cheaper. The two opposite qualities should, therefore, in good building iron be equal.

The Modes of applying the Material.—With good well balanced material as wrought iron, the question as to the best mode of using it becomes more clear and precise, also its use becomes certain and reliable, and we can now enter on the examination of the forms which best unite with those qualities of iron in producing a high result. What I undertake then to demonstrate to you is—that with modern iron as the material of construction, the conic form on certain proportions makes the cheapest, strongest roof, on the largest possible cale. It consists of the minimum of material all set the best way. This is a large proposition, and in order to prove it I fear I am obliged, as in a proposition of Euclid, to go a great way round about the question; because, before I can show it to be the best way, I must shew it to be better than the other ways hitherto called the best ways. That I will do as quickly as I can, by taking only the best known ways.

The common ways of applying the Material.—I take first the best modern way known to us, the iron beam, or straight girder, top and bottom alike, called a rail, a parallel beam, or a bridge girder. I take a pair of high walls and I lay these girders across from wall to wall (or from wall to column, and from column to wall), and I get a simplest possible roof, perhaps the strongest of its kind.

Now, what is the case of this roof as regards strength. The top is all in compression, the bottom is all in tension; one is in danger of being crushed, the other is in danger of being torn. When either gives way the other's strength is useless; the yielding of one half leaves the other half worthless. This beam roof consists then in two seperate halves, which are independent, even contrary in their action, as neither helps the other. But there is also a third, the middle web, which may, in a deep beam, hold as much matter as one of the others. This beam also is rendered useless the moment the top or bottom have given way. Three things then do different work, in which neither can help the other with spare strength, to supply and make good its weakness; one broken, all three are gone. What then is the case of such a beam when breaking? that only $\frac{1}{2}$ of its strength has been useful. But the case is worse than this, the beam is at least twelve times its depth in length. There are few uses for which it would not be more. Now what does this leverage do? Does it help the beam to carry weight? No! it helps the weight to break the beam.

Let us examine the action of weight on our beam. Let us take not half but the whole depth as effectual leverage for strength. The length of lever then is six to one; in other words, the weight on the beam brings a strain on the top tearing the iron asunder with sixfold its natural force per square inch of section. The strain brought on the top is sixfold that amount, also crushing instead of tearing it, neither helps the other nor participates in its strain. What the third part or central web does, is really to help the weight to tear the bottom asunder, and to help the weight to crush the top at the same time. The middle is a mere instrument for setting top and bottom against each other; it is really the fulcrum which ruins the mechanism. Around that centre acts the leverage. The resistance of the top tears the bottom; the resistance of the bottom crushes the top; the middle helps each to ruin both.

A lever, then, consists of two parts set against each other in antagonistic attitude to destroy each other; while neither yields all is stable. When the weight, the leverage, and the antagonism united, force one to give in, all give way. A lever is a combination of antagonisms, its power of doing work is only a surplus, a balance, a mere difference of opposites, in a strong combination. The result is a large vote with a feeble majority. This same waste of useful force in useless antagonism is characteristic of another set of combinations with which you are equally familiar; I mean the whole group of trussed roofs. You take two walls, and instead of laying from one to another, the straight girder I have mentioned, you lay across two girders, which we may call rafters. You lay them sloping opposite ways, in order that by opposing pressures they may balance each other. They do balance, and if the angle is high the harm is small. As you moderate the height or pitch of the roof you increase rapidly the waste strain. You soon make it manifold, the original weight, and the two beams meeting, push against each other, with high destructive power. They do not only push against each other, but they push against the walls they should unite and support. These walls must be kept from falling by other walls supporting them, which you call buttresses, or more waste. To spare this waste you take another, you take a set of new beams, which you call tie-beams, and you set a pair of tie-beams, joined in the midst, to undo the harm which otherwise the rafter beams would do to the walls. You waste double material to stop harm of your own choice. A roof truss is only, therefore, another form of waste; waste aggravated by the smallness of the slope we select; waste doubled by the precautions we invent to undo it.

First Principle—Unity without Antagonism.—Lever roof and trussed roof are mere modifications of ingenious waste, in the ways in which they have been generally used. The question I now submit is this, whether this double waste may not be avoided? In my opinion it is avoided in my conical roof. I think there is in it no waste. I think every atom of iron in that roof does its own work only. No particle does work of antagonism. In short, it is a congregation of atoms working together for the common support, without counteraction, disagreement, or waste of strength, or means, or work.

This principle of perfect unity of co-operation in the atoms of iron, without antagonism and waste, is one principle and the first peculiarity of the cone. There is a second peculiarity, which I place second because it only grows in importance with the largeness of the scale of the structure. When a structure is small, as in a railway bar, a crossing girder bridge, a bridge of moderate span, the load it may have to carry may be manifold its own weight. A bar may weigh a hundredweight and carry a ton; a girder may weigh a ton and carry ten tons; a girder may weigh fifty tons and have to carry a hundred tons. When, therefore, the scale of structure is small, its own weight may be the smallest element in its work. When the scale of structure is large, its overweight becomes very rapidly its own heaviest load, and may easily become its own heaviest cause of destruction.

Second Principle—Wise Distribution of Structural Load.—The next principle to which I call attention is, therefore, the wise distribution of the load of the structure, and especially of that heavy load of its own material on the large scale. This principle finds its happiest illustration in the cone. The distribution of the load of its own structure is best possible. The cone gives an absolute maximum of sustaining power, when on the large scale this principle rules the structure.

As an example of the contrary of this wise principle of distribution, I take the form of structure most approved in modern practice, and sanctioned by modern science, not always wisely applied. I take the elliptic or parabolic form, so frequently, and within certain limits, rightly applied. In this form the depth is proportioned at each point of length, to the strain at that point; this strain is greatest at the centre of length, and least at the ends. This is right on a small scale, on a large it commits a grave error. The error is this—that exactly in the place where a load produces the greatest amount of destructive effect, there is the place chosen to set the largest quantity of destructive load, and just at the ends where weight would produce the smallest amount of injury, that is chosen as the point where least destructive load is laid.

On the small scale, where the weight of the structure may be insignificant, there may be an insignificant amount of inconvenience from it, and we may afford to neglect, though not ignore it. When the scale grows colossal the danger becomes formidable.

The distribution of the load in the cone is just the contrary of this, and is the wisest possible. Its material is lightest at the centre and heaviest at the outside. We are enabled to remove all the heavy loads off from the points further from support, and to place all the heaviest weight on the points nearest the vertical support. Thus the strain on the matter is a minimum and the weight of the material is a minimum, and that minimum is in the place where more would be harmful, and the maximum is in the place where maximum weight does minimum harm.

The second principle deserves the greatest attention, because the benefit it confers is twofold, and because it is the contrary of that most frequently taught, sanctioned by science, and generally acted on. It was well known as the Fish Bellied Rail, and as the Bow and String Form, but is chiefly distinguished as the Parabolic, or Elliptical Girder, once much made in cast iron, and still largely copied in wrought iron.

Third Principle—Co-operation of Independent Parts.—The first principle I have enunciated as guiding our choice in forms of large structures is—unity or absence of antagonistic action in different portions of the structure, each tearing, crushing, or otherwise counteracting the effect and destroying the use of the other.

The second is the disposition of the useful load of the material of the structure in those places, forms, and quantities, where the injurious effect of its inevitable weight will be the least possible.

There is a third principle, allied with these two, in the cone, and perhaps it is most important of the three, that in every large structure, every part of the whole should be ready and able to render assistance to every other part in the performance of its duty, or in the case of imminent danger. Each part should not merely do its own duty, without hindrance or impediment from another part; but it should be placed in circumstances which enable it to lend all the reserve of its own strength to each other part that is exposed to severe, excessive, or exceptional trial. This principle is rarely well carried out, or recognised at its full value. As I consider it one of the most important principles of the future of large architectural structures, I will illustrate it as fully as may make it clear.

Allow me to premise, that the antagonist principle of independent action of parts is a tradition of your profession and of mine. One of the most beautiful scaffoldings I ever saw was made thus, for the building of a large elliptic arch. The whole of the centering sprung from two points. To every small portion of the arch went two long beams from the two springing centres. The pair met, and they two sustained one stone, or one group. A second pair, starting still from the same centres, sustained a second group, and so on, till perhaps some fifty independent pairs carried the whole arch. This had the great advantage that the giving way of one pair did no harm to any other pair; it was the principle of perfect independence carried out in timber struts.

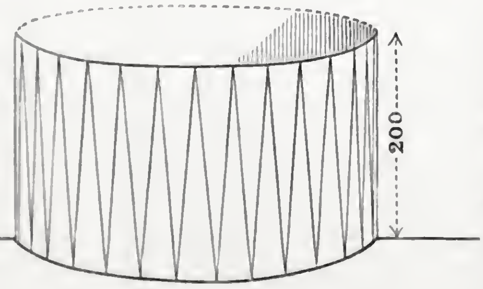
In like manner, you may have seen iron bridges, of the nature of wire suspension bridges, where, instead of the single catenary chain, successive points of the bridge platform were carried by pairs of ties going straight to the summits of the two piers, and thus suspending their portions independently, so that weight on one should not affect the others. By this independence it was intended that the oscillations of the swing bridge should be prevented.

But even without referring to structures in which this independence of parts was a special aim, I may observe that the traditions of your profession and mine, and the practice we have seen, introduced this independence into general use. When I learned shipbuilding we used to put what amounted to three ships, one inside the other. The first consisted of outside planking, intended to keep out the water; the second consisted of a complete vertical frame, to keep the pressure of the water from forcing in this planking; the third consisted of another series of planking, to keep these two discordant elements in position under the action of the waves. These ships were each in general heavy enough to make each a ship; but when it came to a large one, all the three were too weak, and the triple ship went to the bottom.

Well, it was one of the early studies of my early life to try to remedy these evils, I found the same absurd notions of independent action of parts of a ship, which had ruined wood ship building, were being rapidly introduced into iron ship building, and if I was instrumental in contriving and introducing a new principle of construction into modern naval architecture, on which our best ships are built, it was the system of making the whole of the particles of the iron in a ship do effectual work, not in one function, nor in one way only, but by making all the parts of a ship help all the other parts to do their work, as well as each part its own. It is for this reason that the Great Eastern, the lightest built ship in the sea, the cheapest built and the strongest, although the worst treated, has proved able to save herself and her crew and freight; when left helpless to the storm, when torn open by being steered on the rocks, and when distorted by internal explosion. She owes her strength to the principles ennunciated as No. 1 and 3. All the parts of the Great Eastern are one, with the whole and with each other. The skin keeps out the water, but it also supplies the place of a frame, which in her is wanting. Bulkheads divide the ship into water tight compartments; but these bulkheads carry the decks, give shape to the ship, and form part of the masts. The decks carry the goods and keep out the water; but they too are of iron, are integral parts of the hull, and give the strength against the sea required by her great length. The coal bunkers, which once were loads to a ship, are now mere spaces left between her integral portions of iron in the hold. Even the engine frames are built up parts of the ship, and equally save the engines from being strained and the ship from straining. The very divisions of the cabins are partitions of iron welded as integral portions of the ship, and when you sit down on a velvet sofa, or sleep on a luxurious couch, you will find that the bottom of the sofa is welded to the ship, and forms there a part of the general support of the strain. Thus the ship is a great whole, each part helping each, and so neither the hate of her foes nor the folly of her friends have yet been able to destroy the Great Eastern. It may, perhaps, seem to some of you to be unnecessary for me to have done more than state so axiomatic a truth, as that a great structure should form of all its parts a complete united helpful whole, that its strength should not be frittered away by making it a mere assemblage of multitudinous parts, each performing some petty function apart, and contributing little or nothing to the general strength, or to the security of each other. But in truth the great difficulty to be overcome in the introduction of such modern structures as we are now considering, is to obtain the recognition of these principles as imperative laws of practical construction.

Mechanical Nature of the Iron Cone—The Crushing Strain.—An iron cone may be examined and tested in two ways—it may be exposed to pressure from within on the hollow side, or to pressure from without on the round side. I have never seen a formula which explains and predicts the result either way. My conical roof can be best understood by adopting a method of thought, which is, possibly, very different to that generally followed. Nevertheless, as men of eminence, who have looked at it in ordinary ways, have failed to comprehend it, and even been led to false conclusions, you will excuse me if I take you a short simple, but unusual way, to the bottom of this deep well, or to the top of this high cliff.

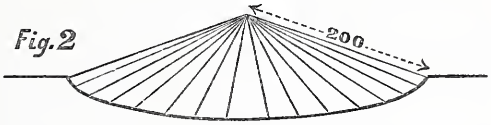
Fig. 1



To understand my conic roof I ask you to fancy a ring or cylinder of wrought iron plate homogeneously rivetted together into one upright plate, 200 feet high and 360 yards round, and say one inch thick. This huge ring, say a few hundred feet high, would be like a large ugly gasometer of unusual hugeness. Let us use this idea to calculate our strength.

Every yard high of this ring—for each inch round—would weigh 10 lbs. It would, therefore, take 672 feet of height to bring a weight of one ton over each inch of ring. The maximum strain possible on the lowest heaviest strained part of this ring, is one ton on the square inch, say one-fifth, one-tenth, or one-twentieth of the safe, or yielding, or breaking strain; therefore, perfectly safe, and far within the widest practical margin. But 672 feet high for one ton of strain is far beyond my wants, I only want for my use less than a third part of that least strain. I take a ring exactly 200 feet high, strained, therefore, to less than one-third of a ton per inch, I ask you to conceive clearly this ring resting on a smooth flat level base—you will see that the strain cannot by any invention be made greater or less than simply the weight per square inch, due to the upright column of metal standing above each inch of base, and diminishing gradually upwards to the summit, ending in O. I next ask you to follow me while I cut this cylinder into pieces, but leaving all the pieces in their places; I now cut the cylinder vertically into couples of triangles, an upright triangle, and an inverted triangle, alternately; I now remove all the inverted triangles, and leave all the others standing upright in a ring as before, points up. I have taken away half the whole iron. I next incline all these triangles inwards towards each other, and they all then touch each other along the edge from heel to point.

Fig. 2



These triangles, say 30 in number, form my cone, they are slightly curved one way, their upright axes remaining straight when inclined, their curvature being diminished exactly in the ratio of their diminishing width. While these triangles lie in that shape, allow me to put perfect solder on all the joints, and to fuse it by electricity. My cone is complete.

Now the conclusion at which I arrive is, that in this state the matter of my cone is nowhere more or less crushed than it was when it had not yet become a cone, and was the original upright cylinder; in other words, the crushing strain on my cone is everywhere less than one-third of a ton per square inch. The proof is simple. The inclination I give the cone being 30 degrees, doubles the upright pressure; but the triangles I have cut away remove half the weight. Half the weight, therefore, with double the pressure, leaves the strain on the material unchanged. This is the speciality of the cone looked at as a self sustaining roof structure. But I can still go much further in economy of material. Having taken away half the cylindrical weight, I am going to take away more of what remains. This I do by diminishing the thickness of the plate uniformly towards the top; when I have done this, only one-third of the whole material of the cylinder remains in the cone, and the maximum strain is still everywhere less than one-third of a ton to the inch. My cone is, therefore, in material only one-third of a vertical round ring on the same base, having the sloping radius of the cone for its height, and its strength and strain per square inch are nowhere greater, and are everywhere less than in the vertical ring. The crushing strain along the slope of the cone is, therefore, extraordinarily small.

The Tearing Strain.—The strain that architects most fear in roofs and domes is the stretching, or tearing strain, which stretches or tears asunder the supporting walls, buttresses, arches, or ties. This tearing strain is readily conjectured to be the great danger in the cone. That this roof should stretch and tear asunder, especially at the lowest ring or outer edge, seems the general first impression made on mechanical minds. That impression leads naturally to the wish to make the outside of the cone extremely strong. Some of my mechanical friends think that there are buttresses all round to resist this. They are not aware that the things they think buttresses are really hung from the roof they seem to uphold.

A simple way to think out the tensile strain of the cone is to study its change of shape as it is conceived to be flattened out. Take my original formation of the cone—30 triangles soldered together in one, now lay them out flat by pushing down the top and swelling out the bottom, and watch the changes: 1st. The radius of the cone base is increased. 2nd. All the conic triangles are sundered, the spaces left between being triangles all with a common summit. The base of the cone was 1,080 feet round, it is now 1,256 feet round; it has stretched 176 feet, or the vacant space forming the base of the triangles of extension is near 8 feet. Call then each of these triangles 8 feet at the base. If the cone had been india-rubber, each triangle of 36 feet material would now be stretched 8 feet out, or have got a base of 44 feet, *i.e.*, stretched 4 feet a side. Now mark the variation of this stretching. Outside it is 8 feet; but 25 feet up it is 7 feet; 50 feet up it is 6 feet; 75 feet, 5 feet; and so on, 4 feet, 3 feet, 2 feet, and 1 foot. In other words the stretching out is perfectly equal on the triangular web all the way up. In exact proportion as the web narrows does the quantity of stretch diminish. Everywhere, therefore, along the web, from outside to centre, the stretch is the same proportion to the length of web stretched.

This is as true of a stretch of 4 inches as of 4 feet. In all degrees of stretching of this cone, in its descent from 30 degrees to a dead flat, the stretching consists in an opening up, which is perfectly uniform along the whole of the cone, from bottom to top. In other words, a force putting the whole cone into stretch by bringing down the top and swelling out the base, makes a perfectly uniform stretch of the whole matter of the cone, from apex to circumference. In short, the whole material is in uniform stretch throughout; but if all the material suffers uniform stretch, that is equivalent to saying, that the whole material equally co-operates in resisting this strain. That is so: every atom of matter in the cone is equally strained, every atom of matter in the cone helps every other equally to resist the common strain, each bears its own share of the common burden. Thus, then, there is neither waste defect nor antagonism, the whole cone is in uniform tension, from top to bottom, and all round.

Supposing, then, a uniform pressure of water, or a uniform fall of snow, to press down the cone top and press out the cone base, it would meet everywhere a uniform tension of iron ring opposed to it. On each ring of iron would press a ring of water or snow, smaller as the iron ring was smaller, larger as the iron ring was larger, and as in my cone the thickness changes with the distance from the top, so will the pressure change the weight and the stretch go together in permanent proportion from summit to base, each ring carrying its own load by its own strength, and all equally strong and equally strained.

I have asked myself what is the greatest strain its own weight could bring on my cone to stretch it. I hang up my cone in the air so that one half shall carry the other. I find 2,000 tons carried by 2,400 inches, again not one ton to an inch. But that is an extravagant case.

We thus see that the whole cone is a series of straight lined tapering bars, starting from a circle and meeting in a point, all of them in compression endways by their own crushing weight. We see that at the same moment the whole cone is a series of circular hoops, increasing in thickness as in diameter, and carrying a strain as hoops, which strain is all ways proportioned to the size and strength of each hoop, and increases uniformly from top to bottom—in size, in strain, in thickness, in strength.

The Combined Strains.—The third important view of this subject consists in looking at these two strengths and strains together.

(1). NOTE. It is the same matter which bears simultaneously the two strains. Each bit of iron is a bit of the straight tapered bar, and stands a crush, and is a bit of the round hoop and stands a tear. Now these two are neither in the same direction so as to conspire, nor in opposite directions so as to counteract each other; one is at right angles to the other; each does its double work, without interference. This is very remarkable.

(2). NOTE. Each atom is crushed one way, torn another way. The same atoms work two ways at once.

(3). NOTE. We may now see how this might end. Let us suppose the cone a perfect whole of homogeneous metal perfectly constructed, symmetrically, mathematically and physically uniform. Let us next suppose it to be systematically and intentionally loaded to destruction. What would happen?

This is the answer: there would be a loud explosion, every atom would be crushed to dust one way and dispersed into invisible particles the other way. Whether what remained would be a liquid or a gas we cannot say, only as iron it would have disappeared, its cohesion and its repulsion ended, we have its complete exhaustion and annihilation. In other words, we should have used up all its possible powers as concrete matter. What more than this can you ask philosopher, or engineer, or architect, to do with the matter God has given us. Can more be possible. This cone then gives the greatest possible amount of resisting power out of a given quantity of matter.

Applications and Modifications—Conic Skeletons.—Forms, uses, and modifications of this conic principle of structure are manifold, and as they all receive light from and throw light on our discussion they deserve study,

I.—DIFFERENCE. What is the relation of a perfect cone to a conic skeleton?

It is one of the peculiarities of the cone that it is a "self contained" structure; in other words, that much of it may be taken away, or injured, or displaced, without destroying it.

I may take my perfect cone, and pierce it full of round, square, or triangular holes all over, and it remains stiff, stable, strong, self-supporting. Nothing is harder than to destroy my cone. You may cut away its centre, *i.e.*, take out the keystone, it will stand all the same. You may cut the outer ring through in many places, the cone will stand. Its power of enduring abuse, distortion and deformation is surprising. I don't think the artillery of an enemy could, in any reasonable time, destroy it.

Nevertheless, I am obliged to say that all modifications of it are weaker than itself. One modification I very early made. I think it good for many uses, especially on a small scale. I call it the skeleton cone. It may be very simply derived from the continuous cone by the following method:—

Suppose you choose to cut away a large portion of the surface of the cone, leaving the intermediate parts all connected together, no matter what the size or shape of the apertures, you may still leave a perfectly balanced self contained structure. This skeleton cone may be very conveniently formed of iron; of iron and glass; of iron, glass, and wood; or iron and wood, in a variety of ways, and will admit of an infinite range of fancy in its applications. One of the earliest applications I made of my discovery of the conic structure, was to use it with an esteemed architectural friend in the design for a large span roof. We designed it together on the skeleton principle; but it was not executed, for the ground was otherwise utilized.

Now I have to observe of skeleton conic structures, that they are light, strong, and convenient, for a multitude of purposes, that I recommend them as stronger, cheaper, and nobler than common trussed roofs; but as the scale grows larger, the continuous conic roof increases in value, and the other loses.

To explain the true principle of the continuous roof and the skeleton, it will be best to cut out the skeleton from a continuous cone. Take the cone already given. Select a portion of it covering say nine square yards, making (nearly) a square three yards on the side. Cut out the central square, you get an opening of nine square feet, with eight yards of continuous material all round it. Let us say you save a yard of iron, or one ninth of the whole. Let us now see by how much this saving of one yard weakens the structure. On the vertical direction which endures the crushing strain, you have removed $\frac{1}{3}$ of the whole strength. In the circular or stretched horizontal strain, you have also removed $\frac{1}{3}$ of the whole strength. Your saving is $\frac{1}{9}$; your loss is $\frac{3}{9}$, in a two-fold use. You have therefore done harm and made waste.

In this example I have cut away only a small opening. Let us next make it great. Instead of one yard in three, let us make it nine feet in eleven. I cut away nine feet in eleven. I leave $\frac{2}{11}$ of the strength first vertically, second horizontally. My saving of material is 40 in 121 $= \frac{40}{121} = \frac{2}{3}$. I save $\frac{2}{3}$ of the material. I cut away $\frac{9}{11}$ of the strength. In round numbers the saving is $\frac{22}{33}$; the loss is $\frac{29}{33}$—I save 22 and lose 29. The saving is also in only one item—Weight 22. The loss is in two items—Stretching strength 29, Strutting strength 29. Much, therefore, as a skeleton cone is a stronger, simpler, cheaper structure than a trussed roof structure, it is always inferior in strength, stability, endurance, and economy, to the perfect cone.

There is another way of looking at this, which is even more striking—not to try to save material, but to gain strength. For this purpose I cut away the same material out of the cone and add what I cut away to the skeleton. In the first case, I cut away $\frac{1}{3}$; I spread that third over the 8 surrounding squares. I therefore add $\frac{1}{8}$ to the strength from which I cut away $\frac{1}{3}$: in other words, I take away $\frac{8}{24}$ of the strength and add $\frac{3}{24}$, $\frac{5}{24}$ of dead loss! In the second case, I cut away $\frac{9}{11}$ of the strength. If I add this matter to the remaining $\frac{2}{11}$, I make it $\frac{6}{11}$, so I weaken it by $\frac{9}{11}$, I strengthen it by $\frac{4}{11}$—a dead loss of $\frac{5}{11}$, or 40 per cent. in the strength. It is plain therefore, I trust, that the continuous cone is the maximum of strength; that the skeleton cone, although much stronger than the common structures, is much weaker than the continuous cone. The conic family, nevertheless, presents manifest advantages, in different degrees.

Practical Application of the Cone at Vienna.—As all structures are not perfectly adapted to all purposes, it is manifestly the duty of the architect and engineer to use each to the end it serves best. Practical duty is a compromise between what one would like to do and what one has got to do; one makes knowingly and reluctantly a sacrifice of what one cannot help, for what one is bound to achieve; whence there are many cases in which one may sacrifice the perfection of the cone for the convenience of the uses. For some such aim, I have been willing and ready to use a mixed structure of continuous cone and attached skeleton on large structures. My Vienna Cone is such a compromise. It has the merit of a complete continuous cone. It has also the convenience of a skeleton cone. It will be necessary to go into much further detail before explaining how and why this is accomplished.

COLUMNS, WALLS, FOUNDATIONS AND ACCESSORIES.

There are two quite different ways in which a conic roof may be applied. It may cover a round building with continuous brick or stone wall, as was first intended at Vienna; or it may have to stand on the summit of detached masses of masonry; or it may have to rest on mere isolated columns:—

1. If the cone is carried on a level even mass of continuous masonry, all its peculiar virtues in strength and economy are utilised to the utmost. So long as the foundations do not give way, and the surface on which the cone rests is true to the surface of the cone resting on it, the effect corresponds to the theoretical result we have examined the best possible. If, however, the surface becomes irregular, if the foundations or wall give way, the case changes, and must be met.

2. If the foundations or the walls give way the cone may be employed to give them strength to keep them in place.

3. If the walls are removed and the cone has to be carried on columns, the cone may be so formed as to give the supports and columns which carry it all the stability and strength they require.

This last case is the actual case of the Vienna Cone. It was meant to have continuous stable walls of brickwork or masonry. This became difficult from want of materials and time. It was next to be supported by columns having narrow fillings between, giving them lateral stability. This, too, was abandoned.

Finally, it was settled that the cone must carry itself, must rely on itself alone for stability, must also carry all the strains of every thing round about it. As for foundations. It has to rest on alluvial soil, and all it can obtain is a concrete footing for each isolated column to stand on. The cone, therefore, has not merely to stand itself, but to give stability and strength to everything else, and to stand the stress of all about it. How a conic roof shall be so constructed as to maintain its own continuity and strength against the yielding of foundations and feebleness and discontinuity of support, and how the cone shall communicate its own strength and continuity to its supports and annexes, is a large New Problem.

4. If we take first the case that the edge of our cone has to rest on detached points, set 36 feet apart from each other, we must soon see that a plate of iron half an inch thick in a round ring will at once be bent into an elastic drooping curve between the columns—in short, that the cone is no longer a cone.

5. The Problem becomes this, therefore:—How to prevent the cone from ceasing to be a cone under the distorting forces now brought to bear on it. To do this we have to provide that at all the points where the distorting forces may be applied it may find the cone too strong for them.

6. Fortunately for us the very nature of the cone supplies the simple and methodical means of doing this in a way of most easy execution. The cone is straight one way, circular the other way. We have only to see that the straight lines are held straight and the round ones kept round, and all the strength in the cone remains.

7. As regards the straight line strength. Each detached column will tend to buckle up the cone at the place where they meet, or to bend the straight ridge line into a curve. To counteract this we must place a stiffening plate running up from the top of the column, and pointing towards the summit of the cone. This need only be an ordinary stringer or straight girder. One of these straight stringers must go from the head of each column and point towards the summit of the cone. It is convenient to call these Ridge Girders, to distinguish them from a second sort to be called Ring Girders.

8. As to the circular strength. Each detached column will tend to distort the cone, by giving it a curious and interesting form, which is very beautiful, but wastes its strength. This distortion would be repeated at every column all round. Happily there is a geometrical and mechanical resource, which is the direct antagonist to this distorting force. Each cone has what I may call a supplementary cone. A small ring of this supplementary cone counteracts the distortive power of each column in the circular direction. All the ring girders in my cone are rings taken out of this supplementary cone. The supplementary cone is geometrically one whose vertical angle makes, with that of the chief cone, a complete sum of 180.°

Ridge Girders and ring girders are therefore the antidotes to the distortive and destructive forces which unreliable foundations, irregular support, or detached isolated columns apply to destroy the continuity and geometry of the cone.

Earthquakes, *Hurricanes*, *Avalanches.*—There is yet another set of forces distortive and destructive of the cone to be kept in mind—an earthquake, a hurricane, an avalanche.

Earthquakes, as far as I have watched their effects in the East, are the architect's most deadly enemies. Nevertheless, the dome of St. Sophia, at Constantinople, has wonderfully withstood them. This I attribute to the fact that, in my view, the dome is built on an entirely different principle from what is generally considered as the principle of the masonry dome. I am not aware that there is much to fear from earthquakes at Vienna; nevertheless I have done my best to strengthen my cone even against them. The means, however, are of the same nature as strengthening against a hurricane.

The hurricane and the earthquake are in some respects the same in their mode of destruction. The earthquake shifts the ground from underneath horizontally away from under the roof weight, so as to leave some load in a position of instability. The hurricane shifts the roof weight away from over the supports, so as to cause instability. The practical effects of both are analogous.

There is one way to insure the stability of a domic roof resting on columns; that way I have already in part described, in the structure I have given to the roof, in ring girders and ridge girders traversing the cone through the summits of each column. These I applied to prevent distortion of the cone by the columns under the action of local disturbing forces.

I must now open up a somewhat larger view of the subject by showing how I can bring all the strength of the cone to bear on the columns, so as to give them and itself perfect stability independent of bad foundations, shifting foundations, shaking earthquakes, and shaking hurricanes. My cone is so contrived, that if you knock away the foundation of a column, the cone will support the column in its place, and the column will support the arches that spring from it and the outer roof that hangs from it, even when the foot of the column hangs in air! My cone is sufficiently strong to carry even two or three adjacent columns with their foundations fallen away. My cone is so contrived, that if by an earthquake the foundations were moved horizontally, the columns would not follow them but would maintain their upright positions in their correct places under the dome. If a hurricane could be conceived strong enough to shift bodily along out of place the whole 4,000 tons of dome, the columns would shift place with the dome and carry it as secure as ever in the new place!

The secret of this quality consists in a principle I have not yet adverted to. The perfect homogeneous cone has a remarkable characteristic which is well known geometrically since the early ages of geometry. This characteristic is, that its whole surface consists in a continuous series of parabolic chains, or approximate catenaries, in planes parallel with the slope of the cone.

Now, these parabolic catenaries have this quality, that they connect the summit of each and every column with the whole of the opposite, as well as with the adjacent, side of the cone. Each column is, therefore, held in place by the equivalent of a countless number of chains ending in the summit of the column, and pressing with a uniform, even-spread, gentle pressure on the skin of the cone, on one side, and also on the opposite side. The weight of the cone on one side anchors the columns on the other, by a series of "iron chain cables," or parabolic catenaries.

But further: each vertical section of the whole conic surface is a hyperbola, approximating closely to the inverted catenary, or catenarian arch. If, therefore, you knock away, one, two or three columns or their foundations, the mutilated cone still stands upright on all the other columns, standing on a series of catenary arches, extending across the whole skin of the dome to the surviving columns, and supporting the roof by catenary equilibrated pressure.

My conical roof therefore contains within it strength enough to resist all the strains which can fall upon its supports and connections, and that strength communicated to them through the best possible ways. To utilise this strength one more condition is necessary, which I have not yet pointed out—that is, the perfect unity of the superior structure, or roof, with the inferior structure or supports. In a common building the supports, columns, arches, walls, find their strength in broad and deep foundations, whence they carry stability up to the roof. In my building all the stability is derived from the roof, and is given off into the supports by a connection to which I must now direct attention.

The roof rests on thirty—or say thirty-two columns, for there are two small side arches at the main entrance. These thirty main columns are neither square nor round. They are ten feet through one way, four feet through the other way, and eighty feet high. They are of the same material as the cone itself, combined in the same proportions, and united in the same way. They are in structure, though not in shape, part of the cone.

The reasons for the position and proportions of the columns are the following :—If the columns had been placed the broad way round the circle, they would have formed part of the wall enclosure, and would also have given more direct support to the edge of the cone. But in this case they do not form an outer wall, they are inclosed in the circular aisle or alley, which is forty feet wide, eighty feet high, and goes right round the building, enlarging its diameter from 360 to 440 feet. In this position they do not serve as walls, and placed circular wise the columns would obstruct the view of the dome from the aisles, and of the aisles from the dome. This is one reason for their radial position. But there is a weighty mechanical reason for this position, which will be recognised by studying the top of the column at its junction with the cone. Here it will be seen that the column carries the cone, and also carries the outmost ring girder, and in this way extends its support continuously round the edge of the roof, and thus dispenses with wall support. Its longer dimension stretches radial wise towards the cone axis, and spreads out from ten feet to a breadth of twenty feet, where by a circular curve it joins the cone. Not only does it join the cone at twenty feet within the circumference, but throughout this distance it becomes incorporated with the ring girder, through which it is continued along the slope of the cone upwards towards the apex. Besides, at the same place there is placed a second ring girder, expressly set there to receive the pressure of its inner edge, and spread its pressure round the cone. The column thus becomes one with the cone itself, one with the system of radial girders, one with the system of ring girders. Thus each gives strength to all, and all give strength to each.

Destruction of the Cone.—It is now, I hope, plain why the whole structure, which merely rests its weight on the ground derives no lateral strength or stability or power of resistance from its foundations. These are mere slabs of concrete which rest on the alluvium of the Danube and prevent the weight of the dome from sinking down into it. The columns spreading out above by ribs and rings over the surface of the cone, may be said to grow downwards from spreading roots above, and merely to rest on the ground, as a lame man's crutches, or as the legs of a table on a smooth floor. Their strength comes from above, not from below. They lend their strength to save the strain of all above them, and they get in return the strength and strain of all above them to maintain their position below. No parts can fall unless all else fall along with it.

To conclude this exposition of the special principles involved in the construction of this Vienna cone, I must beg leave to ask you to take a parting look at it from quite another point of view from that in which I have thought it necessary to introduce it to your consideration. I may in some points have failed to make the principles I have laid before you convincing to your reason—I may, perhaps, have failed to make you feel quite certain of the inevitable strength and permanent stability of my structure as a whole. I beg you, therefore, to accompany me to a new point of view, and thence to look back on the whole cone as a completed structure, and from the outside let us look at it as mechanical critics, and see if we could invent a plan how to make the building fall. For this purpose I shall "defy" the enemies of the building to make it fall. Let them imitate the enemies of the Great Eastern. They blew her up, but she held together! They ripped open her bottom, but she safely crossed the ocean! They abandoned her to a hurricane, but she rode it down! Now, in the same way let us conceive the enemies of the dome trying to destroy it. A friend of mine and myself have already performed that war on a small model. We got it made of metal, true in all its proportions. We blew it up; we squashed it down; we tore it asunder; we buckled it in. At last, by the use of forces out of all proportion to its own weight, we cruelly defaced, deformed, and distorted it. Nevertheless, this deformed, defaced, diabolically injured form remained one complete, self-relying, self-contained structure, and satisfied me that it might be cannonaded, blown up, cut down, undermined, and would still retain strength, stability, and endurance.

Looking, then, at it from the outside, let us suppose it cannonaded by a naval battery of shot and shell. What would they do? They would simply go through, exploding within, and leaving large holes behind them. And these holes, what harm would they do? They would merely do this: make out of the continuous cone a skeleton cone. The skeleton cone would, as I have already shewn, be a weakened cone, but still stable and self-sustaining.

We will next allow the enemy, become savage by failure, to scale the dome, and at leisure with hatchet, hammer and chisel, try to cut it down. Led on by scientific engineers, they will attack the stronghold and try to destroy that at its weakest point. Now the enemy think that the cone takes all its strength from the outer round ring. They think that is the one hoop of the cask, and that when that is cut through all the other parts of the edifice will fall asunder like the staves of an unhooped cask. Let us, therefore, give them full swing and follow their work of destruction. They mount the roof. They use an army of hammerers. They cut through the entire outer ring between the two entrance columns, over the centre of the arch, and they expect then to see the keystone of the arch fall out, and the whole series to tumble like the Barentin viaduct—a similar succession of arches. There one arch broken brought down all. Here, as we stand still, we see the main arch cut through; but everything stays as it was! Why? Because all the other parts conspire jointly to keep it where it is—it is firmly held there and cannot budge!

Let us now try another plan. Let us cut off these other arches and columns from coming to the rescue. Let the enemy go on and sever arch after arch all round the outer ring until the outer ring is cut through into thirty separate parts! Of course it is no more a ring—it no more does work as a hoop. Why do not the arches fall? Why are not the columns upset? Why does not the roof go squash down? The reason is, it cannot budge. Reserve forces far behind, of which the enemy has no conception of the existence or whereabouts, come into play, and the wounded abused building holds its ground.

Perhaps you will say this is the severest test it can be put to, and no more can be done. It can stand still more. You have cut away the outer ring, and it stands. You may go further, and you cut in thirty pieces the second ring. The building stands. You cut through finally the outer cone itself in thirty sections, where it lies between the outer rings; leaving, if you think, thirty clear wounds of thirty feet long each, right through cone, rings and all. The whole building still stands fast. The enemy, disappointed in his aim, will not yet say he is beaten. He will say that he has only proved too much. He thinks that he has shewn that the severed rings and the severed cone were no use as the building stands without them! He will not, however, get you, I trust, to agree with him. He has only shewn that my reserves of strength were too powerful, and that he did not know they were there.

The secret of these reserves I now betray to you—it was the root at the top of the columns, and the catenary chains and arches in the central body of the cone, which were the secret reserves he wot not of, and they held all in place after his destruction was done. These saved the cone, and with these it is still in shape and perfect balance.

The cone, therefore, will stand after it is pierced through all over; after its outer and inner rings are cut through; after the outer chain of the cone itself is severed. Indeed, after it is severed into thirty detached fragments it will still stand. Only complete disintegration can bring it down. Indeed, it would cost more time and labour to cut it to pieces than to build it in place.

HISTORY AND PRACTICAL EXECUTION OF THE VIENNA BUILDING.

The History, Purpose, Plan, and Practical Execution of the Central Iron Dome of the Great Vienna Exhibition, and its surrounding buildings, are matter for a large volume; but that you may judge its merits and demerits, I will hastily sketch the story and the plan, leaving those better qualified than myself to give the professional details of architecture and decoration.

I believe that the general plan, aim and design of the Great Exhibition at Vienna, came like the general idea of the Exhibition of 1851 in England, from the highest quarters. The Emperor and some members of the Royal Family took the initiative in that, just as Prince Albert, and the three or four men whom he called in to work with him, initiated the First Exhibition. The royal family own the park or Prater, just as here the sovereign once held the land of our parks as private property. They made serious sacrifices, and were blamed by their aristocracy for sacrificing the park to the people, just as it may be remembered our prince was blamed by our aristocracy for daring to sacrifice the exclusiveness of Rotten Row to the science and art education of the English people in 1851. The origin of the Exhibition Palace of Vienna was, therefore, similar to our own, and its aim was as patriotic.

His Excellency, Baron Schwarz von Senborn, was appointed the General Director of the Vienna Exhibition, and was well qualified by talent, character, experience, and patriotism for this task. His Excellency had as his executive, in the department of building construction, a distinguished architect of Vienna, Baron HASSENAVER, and an eminent engineer of Vienna, RITTER VON ENGERTH. Under their direction, with an able Professional Executive selected by them, the whole of the buildings were designed and executed.

My Central Iron Dome has, however, an exceptional history, which, in order to render justice to others, I must accurately state. The general design and aim of the exhibition building as a whole, was certainly the idea of Baron Schwarz, or those above him. His Excellency had the experience of all the previous Exhibitions, having been in the Austrian Commission to our first Exhibition. Knowing the faults of all previous Exhibitions, he tried to avoid them. He had also to consider the peculiar climate of Austria, so different from ours, and therefore not admitting or requiring a similar building; and he had to consider the materials of the country, and the kind of skill of their own workmen. Thus his building had to be quite different from ours. We wanted sunshine; they had far too much. We made our palace of glass to get light; their eyes, dazzled by too much, had to be sheltered and shaded to keep out sunlight and sun-heat, and yet to illuminate so as to give clear and distinct vision both of form and colour; that was the Vienna problem, and I think you will say their building solved it. Moreover, there was another aim which his excellency's experience made him single out. The last French Exhibition pleased us much by a new arrangement it introduced of symmetric exhibition, where subject ruled the arrangement as well as country. That which was possible in Paris, seemed to be impracticable in Vienna, at least in their first Exhibition. The cause of this difficulty was to some extent the large entrance of the Oriental element among the exhibiting nations. This seemed to render European plans of classification impracticable, and decided the adoption of a classification of the Exhibition on a principle purely geographical. These data will enable architects to see the ruling motives of the structure as originally devised.

The site of the buildings is near a mile long, running east and west. Oriental countries had the east end; America had the west end; and between, the countries held their exhibitions in geographical succession. To each country was assigned a separate building; each building had its own entrance and exit, as well as its own gardens around it. This series of Exhibition buildings, appropriated each to a country, and left entirely to that country to occupy as it pleased, was the fundamental idea of the Exhibition. These buildings were all parallel, running north and south, and each some 500 feet long, and 50 wide, and 50 high. At first sight it will appear that a large building like mine could have no possible relation to such a plan as this, consisting of sixteen straight buildings, all pitched like tents at a fair, covering a single large field; and that was the idea entertained by some wise men, but not by the Baron himself, who had the idea, that just because the general buildings consisted of numerous rows of similar parallelograms, it required more feature, more order, a beginning, a middle, and an end.

The following is the origin of my large iron dome :—Soon after his Excellency had been selected as chief commissioner, an old friend of mine, occupying an important engineering position at Vienna, who had executed large works on the Lombardo-Venetian Line, and who had been associated with me in some other railway work, told his Excellency that he knew I had long ago designed a structure of unusual dimensions, and of extraordinary qualities, on new principles, and just fitted for an Exhibition of all nations, and he suggested that such a building might give distinction and character to the Vienna Exhibition, just as Paxton's building had done to the London Exhibition.

As matter of fact I designed this building with a view to the Exhibition of 1851. I discovered the peculiar qualities of the conic form with relation to large buildings of modern iron, earlier than '51, and I should have liked to have erected my first cone on that occasion. But as I was one of the three or four original proposers and founders of the Exhibition of 1851, and as H.R.H. Prince Albert selected me to assist him in carrying out that Exhibition, by making me first secretary of his royal commission, I became debarred from even proposing any professional plan of my own invention. I had, however, the pleasure of proposing Sir Joseph Paxton's plans for the acceptance of the commissioners, and of seeing them succeed. My own plans I reserved until the Exhibition in Vienna, and I hope your approval will reward me for the long delay.

When, therefore, in the summer of 1871, his Excellency visited me in England, and explained to me his views of the general plan of his group of separate buildings, I was quite prepared with data for him as to size, character, and cost of a great central cone. At first he doubted the possibility of reconciling the seeming discordance between long rows of low, monotonous rectangles, and a lofty, towering, circular centre. But he became equally convinced of the absolute necessity of a central feature for comeliness, and of the wisdom of having some new, striking, prominent feature in a building of which one of the aims was the education of all the visiting nations in principles, and methods, and materials of modern buildings and public works. In the summer, therefore, of 1872, Baron Schwarz initiated me in his views of the aim and destiny of this building, and I initiated him into the principles and structure of my iron cone. On that same occasion, his Excellency endeavoured to ascertain whether the authorities in this country, whom he as an Austrian commissioner had helped cordially on two occasions with our two great Exhibitions, would with equal cordiality offer to Austria every assistance in their power, for her first effort to follow the good example of Prince Albert. I regret to say, that we neither displayed gratitude nor showed cordiality. The practical result of the visit to the official persons, who should have given encouragement and assistance, was discouraging. The cordial co-operation and effectual assistance of the English nation came later, but it did not come from the official quarters whence it was rightfully due. It came exclusively from the Royal family, and from the best class of English manufacturers and exhibitors. Thus we were saved from the great official and political blunder of withholding from a friendly European state cordial and effectual co-operation in a great, peaceful international effort, for the advancement of science, industry and art. This, however, was not done till much later, when the Prince of Wales, his commissioners, Mr. Philip Cunliffe Owen, and the numerous body of English exhibitors, came gallantly forward and saved our character.

Meanwhile, Baron Schwarz left England, and I proceeded to study and prepare for him designs of an iron conic dome, which should reconcile great magnitude with moderate surroundings. The building first designed was a cone of 800 feet on the slope; that designed second was 400 feet on the slope. My original cone, intended for 1851, was also 400 feet.

The considerations which settled the size of the Vienna Dome, were mainly the cost. It was decided that the central structure, and as much of the surrounding buildings as should be capable of permanent utilization, should be permanent. Of course the cost of the permanent building is greater; but the cost of the permanent building is an investment, and of the temporary building is waste.

I now come to the manner in which I arrive dat the best mode of adapting this large cone to the central position it was to occupy in the surrounding group of parallelogramic buildings. I hope you will give me due credit when I tell you that instead of drawing out an ugly engineering plan myself and afterwards calling in the assistance of the architect to make my ugliness beautiful, I requested and obtained the cordial co-operation of Mr. John Crace from the beginning. Mr. Crace is well-known to you, and his father had been known to me from the beginning of Exhibitions, by the part he took in the interior embellishment of the Original Palace of 1851, and the more conspicuous part he took in hiding some of the ugliness of 1862. I then explained to him what was then the secret of the principles of conic iron construction, and requested him to consider carefully the means of rendering that construction, which I showed him possessed such exceptional strength, harmonious and seemly in association with other architectural structures. From this moment I must therefore say WE instead of I in my narrative. We decided, after many conferences and much thought, on the following arrangements, which were carried out in the various plans and in the execution of the work. On the ground plan, we reconciled the round form of the centre with the surrounding parallelogramic forms, by enclosing the round centre in a large hollow square, that square being composed of these surrounding buildings themselves. The intervals between the square and the round we left as gardens. We next effected the communication of the round with the square buildings by one longitudinal avenue, which passed right through the central circle across the parallelogramic buildings at right angles, so effecting perfect communication of the central circle with every one of the others, and at right angles to this we placed the two great transverse entrances.

The cone we carried on a circular exterior wall of masonry. This was afterwards abandoned, for want of time to do the building, and the cone had to carry itself without walls. For the lighting of the cone we selected a second or upper cone, as most suitable to climate. For beauty we added a third or crowning cone. We also allowed but little light to enter the sides, believing the light from above to be sufficient and effectual. This was much disputed, and strongly denied. But the sight of the interior on the opening day, settled the question for ever. The light and the shade were equally a success, the light falling on the objects we wish to illuminate, and the shade falling on the eyes that look at them.

These being the general features of the original arrangement of the Exhibition building as a whole, and of the central building as part of it, I may now call attention to some of the points in the conic construction, which are of an architectural nature, and gave us considerable thought.

I have already described the mechanical structure of the cone as regards strength, duration, and economy. You know what function is performed by those long ridge girders and circular iron rings, which you see outside the cone. What gave us difficulty was the decision (1) Whether these should be entirely inside? (2) Whether one class should be outside and another inside? (3) Whether both sets should be, in half the size, both outside and inside? I may say shortly that I should have liked the look of them constructively on the inside, as large symmetrical panels are convenient for decoration. But they would have had the radical fault of blocking the light. This we could have avoided by putting the rings outside and the ridges inside. The fault of that is that the ridges and the rings, on the same side, help each other. What decided me to place them outside and turned the balance was, the climatial use of them. The Austrian winter has deep falls of snow, which lie long and freeze hard. I am familiar enough with the climate of the Alps, to know that frozen snow and ice sliding off a roof with a slope 200 feet long, would seriously damage the surrounding lower buildings on which they fell. The rings and ridges keep these sliding masses in the places where they fall, until the advent of warm weather slowly melts them, without harm either to them or the surrounding buildings. One word more on the ridges. They seem to me to give a good expression of strength on the outside which is not wanted inside. The ridge girders of the lower cone, spring directly from the summit of the large interior columns. They continue up the face of the cone to its summit, where each of them carries on its summit one of the bearing columns of the upper cone. Thus thirty bearers do support and seem to support thirty columns. I think this expression is good and useful, and it is to me pleasing. The rings strengthen the ridge girders, and in the first plans we made the ridge girders prominent but the rings lighter than as they are executed.

Having now given the general description of the aim and design of the Exhibition Building, and the history of the design of the cone, as well as its theory, I now come to the facts of its execution, erection, and completion. When it was decided that the conical construction was adopted, I was asked to prepare plans and specifications on which tenders might be received for its execution. I prepared these designs and specifications with the sole assistance of Mr. George C. V. Holmes, a young engineer of Crewe, a student of Downing College, Cambridge, and a holder of Whitworth's Engineering Scholarship. He also under the chief commissioner, afterwards superintended their execution to the opening, and had as his assistants Mr. L. Crace and Mr. A. James. The contracts for execution of the work were tendered for by two of the best English firms, selected by me; two of the best French firms, one selected by me; two of the best Belgian; and several of the best German firms. The prices of three of these were lowest and were nearly alike, being all betwixt the two limits I had given of reasonable price. The tender of M. Harcourt, of Harcourt, of Westphalia in Prussia, was the lowest. The English tenders were the highest. Whether an English constructor of great iron works or a Prussian one does the better work or does it the better way, it is not for an English engineer with patriotic prejudices, to say. I think right to say, however, that they set about every thing in quite a different way, and look at it from quite different points of view. To the credit of the Prussian contractor, I am bound to say, that I have seen some of the largest iron bridges of Prussia thoroughly well executed by him—that he takes thorough interest in the work he undertakes—and that he performed the great feat of executing his work in a time, which many deemed impossible, so that on the opening day the great central cone was perfectly ready, and fulfilled its first function of being the scene of that great international ceremony—on the 1st of May—when the Emperor and Empress and other members of the Royal family, with our own Prince of Wales, and other representatives of civilised Europe, inaugurated the fifth of these friendly concourses of civilised, educated, and industrial nations. Much had to be sacrificed both in the perfection of execution, and in the beauty of decoration, to the necessity of erecting the largest dome of the world in the least possible time. Had there been reasonable time, much might have been done that was not. Many critics find fault with this as with other works, forgetting that in modern engineering, and in modern architecture, we do things that we ourselves know are not the best we could do, and would do. But our masters could mend all that, if only they would make up their minds earlier, and give us more time. Let them take this hint, and let them give us years instead of months to do the next exhibition buildings, and they shall see what we will make of it.

There is one peculiarity in my Domic system of construction, which has not been carried out in the Vienna dome, on which you as practical builders will place great value. It requires little or no scaffolding for its erection; in short it is its own scaffolding. I designed it all in handy little pieces, many of a size, so as to be all set in place one by one, and so that each should carry those above it. This system saves enormous time, money, labour, and waste. This system, however, was not the system of erection in Vienna. I must, therefore, explain how it is to be done, in order that the next constructor may have the advantage of using it. Once more I have to take as a practical precedent my method of constructing iron ships, and as an example of it the Great Eastern. When we were preparing to erect the Great Eastern on the slip, my ship builders sketched out the usual scaffolding, which in those days was generally considered essential to the construction of a ship. It was a huge combination of logs and planks, and formed a continuous staging, on two sides of the ship, 700 feet long, and seventy feet high. I got out the cost of this and found it would waste a sum of 20,000*l.* I threw the plan aside, and laid down the system of systematic progressive procedure, in which the part of the ship erected, forms the scaffolding of the part to be erected, and the cost of 20,000*l.* was reduced to 1,200. The system consists in the following method: 1. Similarity and symmetry of parts, so they are all handy and manageable. 2. Perfect precision in form and execution of parts, so that they all fit exactly in place without adjustment or alteration. This I insist upon instead of things being done as they generally are, nearly right but not quite. Moreover, I insist that "perfectly exact" is easier done than nearly exact. I can show that it costs less money—only it costs more brains. 3. The sub-division of the work, so that multitudinous groups of workmen can work in separate gangs, perfectly independent, each with its own supply of tools, machines and power. 4. Skilled executive well instructed by their master in the right method of procedure. This method of procedure also reduces unskilled labour of every kind to a minimum, and gives the highest value to the skilled workman over the unskilled.

Now my original design was to have executed the dome at Vienna on this method. It was done the contrary way. The reasons were as follows: First, the contractor was a Prussian, who had ways of his own, and who had a staff used to ways of their own. When, therefore, it was settled that he was to do the work, it was thought wise to let him take his own way, because all his people were used to it, and because there was not time to teach them, even if we were willing to take that trouble, and if they wanted to learn our ways. They were, therefore, left quite free to adopt their own way, it being their own work, and the plan they adopted was the following: the iron was made in Belgium—was sent to Westphalia—was there manufactured into large sections and pieces, as large as a couple of waggons could carry and the railways allow to pass. These large sections sent by rail to Vienna, were delivered on the grounds, moved on waggons and rails into place, and then raised by machinery either by steam engines, or where the means were very large, by an army of men, using a battery of screw jacks. The method of erection was this: Each column was made at the works in five parts. The top sections of all the thirty-two columns were first set round in a circle, and then all joined together by the ring girders of the outside, and by the outer circle of cone plates. Then the whole of the thirty two capitals of the columns, and the whole entablature 1080 feet round, were raised by screw jacks into the air, and when twenty feet high, the next upper portion of each of the thirty-two columns were stuck in below the capital and the whole was left resting on that, while the capital was rivetted on to the shaft by lap plates. The next process was to lift all these once more into the air twenty feet higher, and set in other thirty-two pieces of shaft below these, and so on till all five parts of the columns stood under each other. The outer ring of the roof was then in place.

Thus the outermost roof and rings were set in place ready to carry the lower cone. But there was an inner ring necessary to carry the upper or second cone. This upper ring stands 150 feet high, and the thirty columns of the upper cone spring from it to a second entablature. An entire central scaffolding some 100 feet diameter, and two hundred feet high, was erected here to carry the upper ring, and the ridge girders were then hoisted into their places. These girders were next connected with portions of the cone previously rivetted into sections, and on them were applied the outer rings. Thus all the work was done in large sections instead of small.

I leave to others to judge the comparison of the two modes of erection. Erection in mass with much scaffolding and machinery: erection in detail, bit by bit, each sustaining the other. Perhaps the truth is, according to the proverb, that " the way you know is the shortest way," so here each of these two ways is the best, when it is executed by those who know it best by experience of its use.

The erection of the building by the Prussian contractors, was effected under the direction of the Austrian Commissioner of the Buildings—Ritter Von Engerth, and his staff, and was carefully inspected, recorded, and reported to me, by the resident Engineer, George C. Von Holmes, and his assistants. The architectural features and ornaments of the central dome, are all executed from the designs and under the personal direction of the Commissioner of the Buildings, Baron Hasenauer, and his staff. It will be seen from the extensive series of drawings by M. Hasenauer, which accompany this Paper, that the great dome is not, as many suppose, a mere separate isolated structure; but that, it is incorporated with the vast area of smaller buildings all round it, so as to be an integral portion of a whole group.

I have been much blamed by some architects and by some engineers for this arrangement. I take the blame willingly, for I think the measure seemly and wise. They say, you should have carried up the walls of your dome much higher. You should have done the great size of your gigantic dome justice, by making it look down from sublime height on all around it; they add, that in consequence of this fault, when seen first from outside it does not look half its size. I don't know if you, the architects, will agree with them or with me. I am of opinion, that it is sometimes a merit in a gigantic object, not to look big, especially from outside and at first sight. I like that a grand thing should grow on you, and gain rather than lose by closer acquaintance. I am told that St. Peter's does not look big at first sight and disappoints those who go looking for bigness. I know that Milan Cathedral did not to me look big, but it grew on me day by day, until I thoroughly grasped its structure and gigantic proportions. I was, therefore, a willing party to the plan, that the dome should not uselessly overtop the surrounding buildings, but they should culminate in it as a crowning part of themselves.

I think, also, that you will agree with me, that the architectural structure and the systematic decoration, not merely of my building, but of all the surrounding buildings, is wise, appropriate, and in good taste, and that I may be the means of carrying an expression of respect, from the architects of London, to the architects of Vienna, on account of this great international work.

In conclusion, allow me to say that I think it likely this building will stand. For my dome I venture to say that with moderate care, it may last a century or two. It is far stronger than necessary for temporary use, and that gives it endurance. I think it not improbable that it and a proportion of the surrounding will be consecrated to the same use to which we devoted our crystal palace; viz., to the education, recreation, and refinement of the people. The park is magnificent; the surrounding woods are extensive. A new embankment of the Danube has already been made. This new crystal palace will be within a short walk of the city of Vienna, and therefore accessible at small inconvenience and cost. I do not think that a modern national edifice can be devoted to nobler use than a palace, in a park, devoted to the instruction, recreation, and refinement of a people who are obliged to dwell together in a large and crowded metropolis.

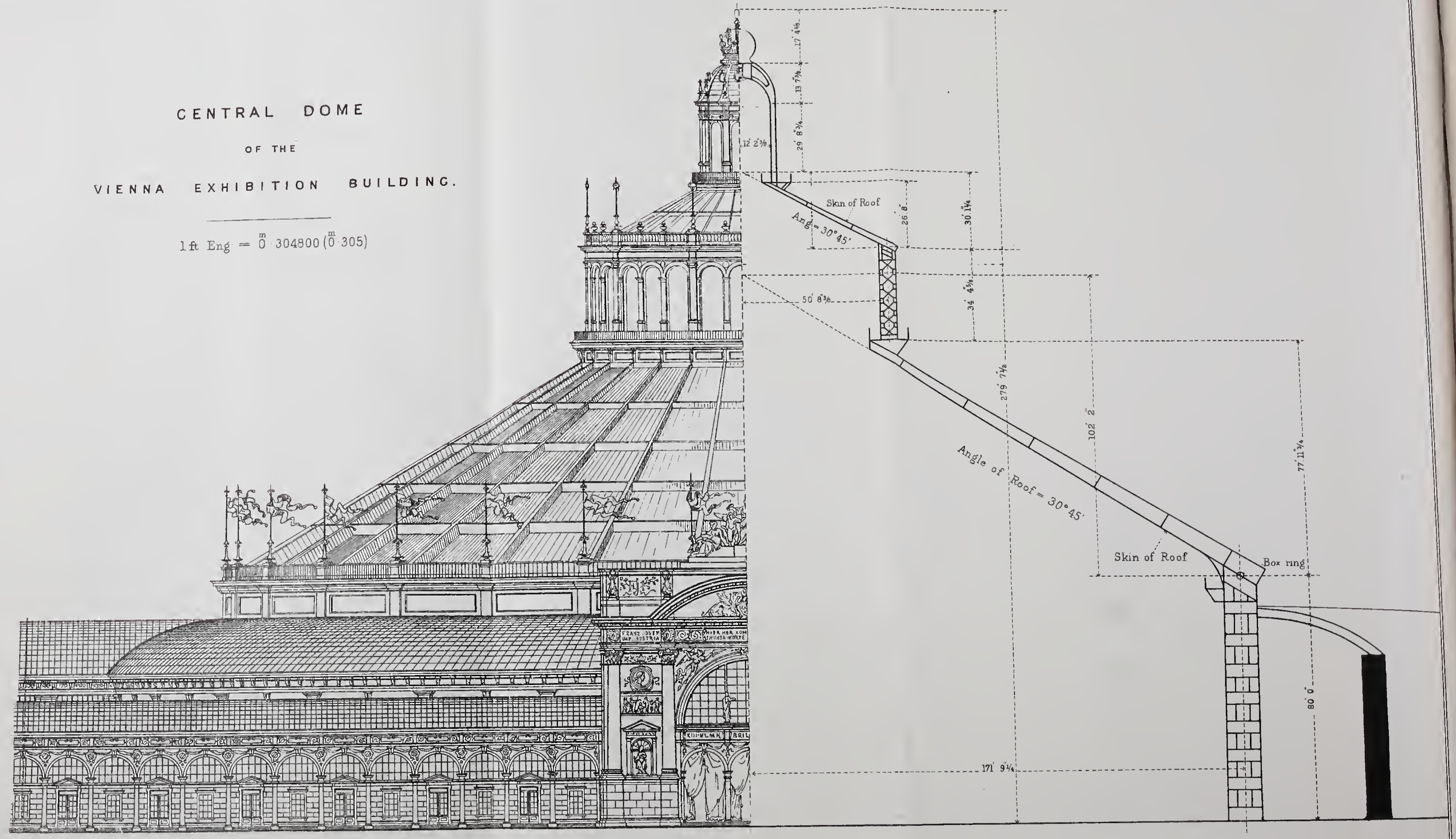
I have omitted to give particulars of the exact cost of such a building; but I shall be able to do so at a future time. Meanwhile, I may state generally, that in ordinary times in England, the cost of such a conic roof, 400 feet diameter on the slope, may be taken as £50,000. That covers nearly 100,000 square feet of ground, being 10s. per square foot. The walls and columns and the decorations may be taken as a further cost of 50,000, enclosing a cubic space of 10,000,000 cubic feet. This gives a cost of ten farthings per cubic foot.

I have also been asked what size I should be ready to give the next building of this kind. I reply that 800 feet on the slope would be made at little more cost per cubic foot of contents of the building than the present one. It is the virtue of this conic construction that it can be made at moderate cost of far larger contents than any known method.

A vote of thanks was passed to Mr. Scott Russell for his interesting Paper, the extreme length of which precluded its discussion on the same evening. At the suggestion of the Chairman the Discussion was therefore adjourned until the next General Meeting.

CENTRAL DOME
OF THE
VIENNA EXHIBITION BUILDING.

1 ft Eng = $\overset{m}{0}\cdot 304800$ ($\overset{m}{0}\cdot 305$)



HALF ELEVATION.

HALF SECTION.

Photo-Lithogd for the R.I.B.A. by C. F. Kell, London.

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 23rd of February, 1874, Sir G. G. Scott, President, in the Chair, the following Discussion took place:—

DISCUSSION ON MR. SCOTT RUSSELL'S PAPER ON THE CENTRAL DOME OF THE VIENNA EXHIBITION BUILDING.

The President,—We hope to have a discussion on the Paper, which I unfortunately missed at the last meeting, by Mr. Scott Russell, on the Dome of the Vienna Exhibition Building. If any gentleman will open the discussion we shall be highly gratified.

Mr. E. W. Tarn, M.A. Associate,—I have for a long time taken great interest in domical construction, but in this instance I did not at first quite understand how such great strength could be obtained with so light a covering. The roof may be said to consist of half inch plate iron, without any strutting, carried over a circular space of 360 feet span, being about three times the diameter of the dome of St. Paul's Cathedral. Of course this is not the first example of a dome erected in a conical form; Wren, if he did not discover it, used it in St. Paul's; that dome is really a conical dome. What we see of the curvature inside and outside is simply an addition put on to give more architectural effect. It strikes me—looking at the way in which Mr. Scott Russell's dome is constructed, that it might be carried out in any curved form. Of course it would not have quite the same strength and resistance to compression from above as the straight line would have; still that might be got over; and considering the matter as Mr. Russell has put it, we might have domes having any one of the conic sections for their vertical outline. Circular or polygonal buildings are not so very common, the plans of most of our edifices taking the form of parallelograms. When we want to cover a large railway station such as St. Pancras, which is 240 feet in span by two or three times the length, it appears to me the same principle could be carried out on an elliptical plan; and the roof in such case would be somewhat in the form of a dish cover. No doubt there is enormous strength in the wrought iron cone, as may be seen from the way in which it is constructed. Mr. Russell has explained how he has introduced ribs, which would not have been necessary had the dome been carried on a wall all round; but these were introduced in consequence of the cone resting on pillars 36 feet apart, and in order to prevent buckling. A dome we generally consider to be curved inside or outside, but the principle is the same throughout; so that with domes of large span it appears to me that this sort of material and this mode of construction, are the very best we could adopt. I believe the skeleton form of dome was introduced in the Church of St. Isaac, at St. Petersburgh, on the principle of Wren's dome, and formed of cast iron ribs arranged in a conical form. The dome of St. Paul's is of brick, and therefore it has not that lateral cohesiveness which a wrought iron dome has, although the resistance to pressure is sufficient. I think Mr. Russell has described a mode of conical construction which ought to be taken into consideration by those who have large buildings to cover. With polygonal, circular, elliptical, or other shapes, the same principles may be made to answer, with certain modifications. The same may be said of the skeleton dome, somewhat on the lattice girder principle. Of course the strength is not so great, but sufficient can be got for all practical purposes.

Mr. T. MORRIS, Associate.—I hope I may be allowed to express the delight with which I listened to Mr. Scott Russell, during the delivery of his Paper; and I could hardly help regretting your absence, Sir Gilbert, on the occasion, as it appeared so graceful and appropriate an act for the most eminent of our constructive engineers to bring a treatise upon his great work in the Austrian capital to this Institute, presided over as it is by one who has so recently and so exhaustively described and illustrated the subject of domical construction throughout the world. There was also much to be pleased with in Mr. Scott Russell's manner of delivery. It reminded one of some of those great lecturers we have listened to in this room (such as Dr. Whewell), and seemed to possess the mercuriality of Professor Willis. As exemplifications of economical construction, Papers of this kind have great value; and we can hardly receive a greater service at the hands of an engineer, than in being shown how to apply a given material with effect and economy. I was lately called over some works which had been left to a builder to devise as well as carry out, and I found that the great sub-division of purposes and variety of materials had raised the cost far beyond that which would have followed skilful selection and effective application. Where the same material will serve for the exterior and interior, it is clearly in the highest degree economical. In point of antiquity, there can be no doubt that the conical form of roof is of most ancient character, and of earlier date even than the spherical form. There is, I think, a presumed example in the Tivoli Temple; but so far as architectural form is concerned, I think the cone must be decided to possess great inferiority to the spherical form, as seen in the dome of the Pantheon, and my opinion is that with the means of construction in iron, which these great engineers are now bringing into common use, we shall be able to construct a dome such as has never been seen or at all comprehended before. The ribs and zones will be so nicely adapted and proportioned to the strength and the stress, that we shall have such examples in that way, as will really mark a new stage in domical construction altogether. I throw this out for the consideration of those who may have opportunities—which I shall never possess—of carrying it to some practical result. When General Scott laid before us his drawings of the Albert Hall, I was struck with the kind of curb plate he laid all round the building, and though I do not think an elliptical building is so desirable as a circular one for the purposes of a dome, it seemed to me that one great constructive point had been gained by the tie to the walls, that was given by that iron curb. My idea is that a grand form of domical structure may be achieved by the use of iron ribs, as struts with zones or curbs as ties. The properties of iron being admirable for frames and skeletons, the architect should so employ this material as to obtain its power but conceal its presence—a principle adopted in the works of nature, and especially displayed in our own bodies. Therefore, I think we may be content to take the iron for the skeleton frame, and case it up with stone and other material, that may seem to conduce to the object in view.

Mr. H. CURZON, Associate.—I had not the advantage of being present when the paper was read, therefore I can only speak on the knowledge I have gained from the printed paper forwarded to me. It appears to me that after some preliminary remarks, Mr. Scott Russell's paper was divided into two distinct portions; the first is headed, "General Description of the Conic Dome at Vienna." I think this is not correctly so headed, because it describes a cone constructed of 360 wrought iron plates, tapering upwards, and riveted together, the whole cone being in uniform tension from top to bottom and all round. Mr. Russell asks us to suppose that if a uniform pressure of water, or a uniform fall of snow should rest upon this dome, it would be met everywhere by a uniform tension of iron ring opposed to it. The cone is then described as a series of straight-lined tapering bars, and is summed up as a perfect cone of homogeneous metal, perfectly constructed, symmetrically, mathematically, and physically uniform. And this cone, by its system of construction, would require little or no scaffolding for its erection. I take it that is not the dome now existing at Vienna. That is described in the second part of the paper, called the "History and practical execution of the Vienna Building." The description of the building is very slight here, but we cannot complain of that, because Mr. Russell has bestowed much time in composing and delivering this paper, and we have other sources of getting at what the building is. We have the drawings which are in this room; moreover they have been published in one of the scientific papers, and I find on looking at them, that the actual building is altogether different from the theoretical cone described in the first portion of the paper. I find it has good foundations. I prefer to begin at the bottom; Mr. Russell begins at the top and works downwards. He places no reliance on the foundations; he holds them in no esteem. They are described as mere slabs of concrete to prevent the pillars from sinking down into the alluvial soil on the Danube. That I take to be the quality of a good foundation. Then there are enormous iron pillars rising from those slabs, and connected with a gigantic ring of iron work. From these, connected curbed by knee pieces, spring enormous ribs, tapering upwards. These ribs Mr. Russell calls stiffening pieces. They are five feet in depth from flange to flange, and of enormous scantling; twice such ribs, in depth alone, as you find in Westminster Bridge; it is therefore, I think, rather disparaging them to call them stiffening pieces. They are connected to each other by equally deep rings or purlins forming zones, and the whole thing forms a tremendous skeleton frame, which no doubt is extremely strong. The panels of this skeleton framing are filled in with wrought iron plates. I take it that is the way in which domes have been hitherto constructed, viz.—with skeleton ribs filled in with panels of lighter materials, and these being wrought iron, are capable of covering a considerable panel. I have no doubt it is more useful constructively than slating would be, or than concrete is in the Pantheon; but I fail to see that it has got those "catenaries" about it of which we are told. If this cone contains any of these catenary arches, it is, I presume in the same way that a block of marble has been said to contain a beautiful statue; in that way the parabola and hyperbola may exist in this cone, but you have got to find out where they are. Mr. Russell gave a graphic account of the destructive attacks of imaginary enemies upon this cone. I, in a friendly way, should like to cut out all these panels of wrought iron, and fill them in with slating and timber, and plaster, for the sake of argument, and we shall have a building practically such as we have now, for I am satisfied these ribs and substructure would carry the whole thing. The question then is, what has become of Mr. Scott Russell's theoretic cone? I think the title of the first part of his paper is a misnomer, and may have misled some who were not present. They may have gathered that it is the cone at Vienna which is there described, whereas it is a theoretic idea, no doubt very perfect, which has been in Mr. Scott Russell's brain for some years. I would suggest that the title should be altered, for the sake of argument only, and that we should call the first part of this paper, using Mr. Scott Russell's own words, "The large new problem." To the other part, the "practical execution of the building," I would give the name of "the old, old story."

Professor Kerr, Fellow.—I have been thinking over Mr. Scott Russell's ideas a good deal, for to my mind they are extremely interesting and novel. I agree very much with the last speaker in some of his sentiments, though I am most anxious we should avoid anything like contradiction of a friend who comes before us and favours us with his views so unreservedly. [Mr. Russell. I have not the least objection, on the contrary I like it.] We must all feel an admiration for Mr. Russell's combativeness, but we may still reserve to ourselves the right to treat him with all courtesy and consideration. I confess that a little light has been thrown to-night on the subject of this dome as far as my views are concerned, by what we have discovered in respect of the vertical and cross ribs; and though I do not ask what has become of Mr. Russell's theoretical dome, yet it seems to me we have got back in a great measure to the ordinary principles of construction, and the question we have to put to Mr. Russell, as a matter of information, is to tell us whether the iron sheathing, which we before understood to constitute the cone proper, is or is not structural. If it be merely a filling in under or between the ribs, then we may be obliged to count it as nothing; but if the sheathing be the structure itself, what about the ribs? What are they there for? As we see the case on these drawings it may be described thus—a circular bottom plate is formed, no matter how; and from that there rise upwards at a very suitable and fair angle—30 degrees, I think—a complete series of ribs, at a distance, I suppose of 20 feet apart. [Mr. SCOTT RUSSELL, 30 feet.] Thirty feet is a reasonable distance on so large a scale. They converge upwards towards a great eye in the centre, and there there is a top plate. In this we have the simplest system of conical construction, for the materials, whether iron or timber. Then the lantern which is elevated on the summit is, I presume, of the lightest construction; but here I am quite prepared to admit that there is a virtue in the straight conical form as distinguished from the curved domical form, by which the former would carry such a lantern much more readily. Do you not think so, Mr. President?

The PRESIDENT.—I think so. The cone has been introduced at St. Paul's to do similar work.

PROFESSOR KERR.—Just so. There Wren built a cone, at a very steep angle, of brick; bonded, no doubt, most liberally with iron chain bond, and the function which that brick cone performs is to carry the stone lantern on the top. Of course the principle is the same. The cone of Wren carries this massive stone lantern, and as we all know, the curvilinear dome outside is constructed of wooden framing for the sake of form. It bears on the cone, but it need not do so. However, in this case we have vertical ribs, and then we have them tied together, let us say by circular cross ribs. Now I am going just to hit Mr. Scott Russell once. If our friend's principle of the antagonism of co-operating structural agencies be worth anything, the cone being one agency and the skeleton of ribs being another, if they both act together, and if one should fail, the other must fail also; and therefore, I understand Mr. Scott Russell to say, they must be considered as in opposition and the whole design ought to go into the condition of gas!

Mr. RUSSELL.—What if they help each other?

Professor KERR.—That is precisely what I say. Well, now, the question of the elliptical form is another important matter that has been suggested for discussion. For instance, the Albert Hall is built on an elliptical plan. I have heard it said amongst engineers that the roof ought to have fallen long ago; as if it were sustained upon some occult principle which nobody clearly understands. But Mr. Salomons, who was here when Mr. Scott Russell read his paper, explained to me that this is quite a mistake or a jest. For it is constructed in a comparatively simple manner, with ribs, very much like this. There is, however, the inherent weakness of the elliptical form. The tendency of every such ellipse is, I suppose, to become circular. The Albert Hall may be a magnificent building. I do not disparage it; I think it is a most successful work; yet there is that weakness of constructive principle apparent in the roof which we must not overlook, and Mr. Scott's Russell's circular plan is of course much more scientific. I had something to say about the catenaries, but our friend who spoke last has treated them with such fit disrespect, or rather with such an appreciation of what I think to be their absolute want of virtue, that I have little to add. I should like Mr. Penrose to tell us what he really thinks of these catenaries. It may be that I cannot properly follow Mr. Russell's arguments, because the subject is obviously a very recondite one, and one which indeed we need not blush not to understand. But Mr. Russell tells us this: I have got a circular peristyle 80 feet high; upon that I elevate a cone; and the peristyle is kept in its circular form by the cone; and to such an extent is this the case that you may remove two or three of the columns and nothing will happen, because all the rest will be held in their places by means of parabolic and hyperbolic catenary arches within the substance of the cone, infinite in number, extending from every point to every other point (the one set being upright, and the other set being inclined in all directions), and thus constituting the cone a complete system, infinite in number, of equilibrated supports for the purpose of maintaining the peristyle inposition.

Mr. RUSSELL.—Quite right without the word " infinite."

Professor KERR.—Indefinite, then, we will say. Well, I challenge my friend Mr. Penrose to explain this. I think if any one can explain it he is the one to do so, and if he does, I for one shall be extremely glad to be informed. The next question that occurs to me is that of the circular form of rib *versus* the straight rib. This is one which interests us all as architects, on the ground of both appearance and strength. If this cone is really constructed on the basis of the vertical ribs, these may just as well be curved as straight, if you equilibrate them with regard to section. The straight rib is equilibrated by being diminished in sectional area upwards; the sectional area of each horizontal rib is in proportion to the lateral strain of tension; and that of each point in the length of the vertical rib is in proportion to the horizontal strain of compression. [Mr. RUSSELL.—Quite so.] Now that could be done just as well with curved vertical ribs as with straight ones. I suppose the lines of equilibration would in the cone be straight lines—there would be two straight lines for the flanges of the straight rib. Then there would be two curves for those of the curved ribs; and although these two curves might not correspond exactly in the same way as the two straight lines do, yet equilibration is perfectly easy, and then we should have what I think most of us would desire, the curved outline in preference to the straight, which, though graceful in its way, some will think not so graceful as it might be. It is merely a question of equilibration, whether straight or curved, and the æsthetical problem may be solved in either direction, provided the equilibration be properly adjusted. [Illustrating on the board.] Professor KERR continued.—As regards now the doctrine of perfect iron, I think I understand Mr. Russell to say this: We know very well that in the case of a cast-iron girder (I am now dealing, I know, with the most elementary matter)—in the case of a cast-iron girder we make it of the form so well known, with the bottom flange theoretically six times, practically about four times the section of the top flange; the reason being that the resistance to compression is in cast-iron six times greater than the resistance to tension. Then Mr. Russell says that perfect wrought iron ought to have the two strains equal; so that if we take any section of H iron, with equal flanges, then that is a beam which ought to be, if the iron is perfect, absolutely devoid of waste. I am not sure that he is quite right about that. We know what the section of an ordinary plate girder is. The top flange is made 25 per cent., (some appear to say 75 per cent., but that is absurd) 25 per cent. in sectional area beyond that of the bottom flange. The reason for this, I apprehend, is, not that there is a material difference between the two *strengths* of resistance in wrought iron, but that there arises a difference in the process of the manufacture of the wrought iron into a plate girder. The top flange has to be a little more in area than the bottom flange, to make up for an artificial difference arising from the riveting together of the material. It is no longer the simple material of rolled iron, but the complex material of rolled iron riveted.

Mr. RUSSELL.—When the lower flange is in several plates, it is best for tension; but the upper flange should be all joined in one, in order to be most favourable for compression.

Professor KERR.—I presume it is found when such a girder fails, that it gives way by the unexpected buckling of the top flange, which, I apprehend, we cannot account for, except as an incident of manufacture.

Mr. RUSSELL.—The lower flange is kept in shape the more it is strained; the upper should be in one solid plate, and then it would not buckle.

Professor KERR.—Very well. Take the H girder: this being the ordinary state of things, Mr. Russell thinks when we have got the material in such a condition of toughness that it will resist tension and compression equally, then we have got a perfect material. Why he says so I do not understand; but that represents the theory which he now enunciates. This common H section would be of course virtually of one gauge throughout, with equal top and bottom flanges; and would indicate, in Mr. Scott Russell's view, a perfect condition of the metal for building-work. Now, whichever case we choose to take, whether of cast iron or of rolled iron, and whether in the latter instance of equal strengths or not, there is this theory which our friend advances under the name of the antagonism of parts. No doubt there is a great deal of cleverness in it; but I want him to explain, because I cannot see the force of it. We have the top flange in compression; we have the bottom flange in tension; we have a web to keep, at all events, the flanges in their places; therefore, says he, you have got three agencies or three separate forces in that iron girder acting in a sort of opposition to each other. [Mr. RUSSELL.—Not the top and bottom in opposition.] Says Mr. Russell truly enough, if one of these three agents gives way, the other two are useless. Suppose they are; the answer is, that we do not intend they should give way. [Mr. RUSSELL.—But when they do?] We do not calculate upon that. The intention of the design of the beam is, that it should not give way; and so long as it does not give way, these forces are not brought into antagonism, but into co-operation. It is important we should understand that all these forces are in combination so long as the structure does not give way, and when it does give way the case is beyond our control. This top flange carries so much load; this bottom flange carries so much more; and the web also carries so much; but if it did not, it serves this most important function to preserve the element of depth, without which the two flanges would be but two bands of iron, which would soon yield to the strain. Having then so far cleared the way, I hope Mr. Russell will now be able, from what I have said, to explain himself a little more clearly to our comprehension. Then I take up, as my last point, our friend's notable illustration. I hope he does not intend it for more than an illustration, and a hyperbolical one, viz., that when one of these perfectly adjusted girders, or any other structure adjusted like the cone before us in perfect equilibrium, does give way in any respect, the whole thing ought to disappear in *gas*.

Mr. RUSSELL.—Not the girder at all, but merely the theoretical cone. I think I rather left that to be understood by each gentleman as he thought best. What will happen to a structure, on which all the atoms are strained in two directions to the utmost, is, I am afraid, a problem too difficult for you or me to determine. Therefore I put that out as a very difficult problem, and he would be a very clever man who could precisely predict the issue of it.

Professor KERR.—Theoretically, that is all very well. [Mr. RUSSELL.—It does not apply to the girder.]

Professor KERR.—Of course the cone would not disappear in vapour. The way in which it would fail, we know, would be from some unexpected weakness appearing in course of time. Whatever the margin of stability may be, it must be reached at some time. This dome, vast and massive as it is, would, in course of time, buckle; it would fail still further if not repaired, and ultimately it would fall to the ground, and the grass would grow over it. It certainly would not go into gas (laughter). A friend suggests that at all events if it did it would be laughing gas. We must have that point cleared up, for it will never do for this Institute to let Mr. Russell think for an instant that we imagine the whole thing could absolutely disappear in space, and we must really ask him to reduce his doctrine to more sober phraseology. But after all there is a great deal of most interesting matter in his paper. One thing, at any rate, that I should like to see done is, that the strains should be calculated, and that some one should tell us how they really stand. As it appears to me, this is a cone composed of ribs; these ribs are subjected to cross strain by the weight of the structure itself. Then the lantern above is a disturbing element, and that induces me to ask whether the equilibration of the rib ought not in fact to be curved, so as to be adapted to the circumstance of the lantern being placed incidentally upon the summit? [Mr. RUSSELL.—Purposely]. Well, as a matter of science, I think the top flange should be curved, in order to carry the lantern; in other words, if such a rib be designed to carry a lantern, then I think you will find that either the intrados or the extrados ought to be curved. Leaving these questions therefore to the meeting, permit me again to express my best thanks to the lecturer.

Mr. C. FOWLER, Fellow, said,—Like some of the previous speakers, I had not the good fortune to hear the paper, which is a very interesting one, though the hearers or readers of it may have been startled by some of the statements it contains. I confess that from reading the paper, I was not prepared to find the construction to be that which the drawings before us show. As has been pointed out by previous speakers, the description of the actual building in Mr. Russell's paper, is rather more scanty, perhaps, than we could have desired. The description of the theoretical portion occupied so much of the lecturer's attention, that he was perhaps unable to go more completely into the description of the actual building. From reading the earlier portion of the paper, I was not prepared to find the drawings showing a construction having such very large ribs and girders, in proportion to the actual space covered. I was under the impression that this cone was constructed upon the principle of a real dome of iron. Some illustrations of the construction of domes were brought before us some years ago by Professor Lewis, including those great domes in India, which are real domes appearing to have little or no thrust, and certainly not depending for strength and stability upon iron or any other ties. I had thought this cone was constructed on that principle, but it appears from the drawings it is not. It is a roof, and not a dome; no doubt a roof cleverly put together, and supplemented in strength by the plates which form the inner skin. The theoretical portion of the paper would lead us to suppose that the skin formed by these plates would stand by itself, but I venture to think Mr. Russell would not trust himself to put up that theoretical cone without the ribs and rings as actually executed. Had Mr. Russell ventured to put up a cone of only half-inch iron, and it had stood, it would have been an instructive instance of conical dome construction. I take it the structural theory of domes essentially requires that there should be no arches, rings or ties, but that the structure should be entirely homogeneous, as the Indian domes are. I was partly led to think the construction to be different, from the reference Mr. Russell makes to the Great Eastern steam ship. I remember reading some description of the construction of that vessel, and my impression is it was built entirely upon the cellular principle, with inner and outer skins forming the actual structure of the vessel—as it were, an inverted dome—and, no doubt, owing to that structure, of great strength. It is the same principle which is carried out in tubular bridges, where all the plates and ribs are put together in a way to form an almost homogeneous structure throughout. That appears to be a great principle of strength, and that principle, to a great extent, I miss in this construction, and I am so far disappointed. Perhaps Mr. Russell will be good enough to tell us how far he thinks he might dispense with these ribs, if he had had the option of putting on an outer skin as well as an inner one, and whether it would not have been cheaper, though more difficult to execute in point of time, and more effectual to have constructed this roof with inner and outer skins, connected by *rib* plates at proper distances, in the same way as the structure of the Great Eastern. I have had laid on the table drawings which were prepared of the first design for the Exhibition building of 1851. You may remember that it was proposed to construct a dome or domical roof, to be built on a system of circular ribs, with cross ribs and ties. I understood at the time, that one of the principal reasons why the dome was not carried out was, that it would have been impossible to put up that dome in the time; and yet that was only 200 feet in diameter, whereas this is 360 feet. I think, therefore, it reflects the greatest credit on the designer, and those who carried out the work, that they should have been able, in such very limited time, to carry out this very large and important structure, as to which, whatever our opinion may be on the theory, we have the great fact that it stands, and has stood a sufficient time to test its stability. The design is in many respects charming, but I confess in one essential respect it is disappointing. No one looking at the drawing of the exterior, as finished, would have the slightest idea how it was put together. No one could conceive that the nicely-designed Italian work was entirely constructed upon wrought iron *boxes*, and it does seem a pity that so cleverly designed a building structurally, should not have been treated architecturally and decoratively in some manner consistent with its structure, instead of that being entirely hidden. No doubt it is a misfortune of engineering works, that the engineer has not time to devote himself to the decorative as well as the structural part of his work, and he has to apply to some one to assist him in that. The architect, in many cases, has comparatively little knowledge of or has not time to investigate the principle of the construction, and merely looks at the form put before him, and makes his design accordingly. He is not able, in many cases, to work out the decorative form from the structural one. We can only look forward to the time when we may hope the designer of such structures may be able to understand both the principles of construction and the decorative treatment, sufficiently to indicate in a general manner what that treatment of his structure should be, so that though he may not be able to work out all the details, he may superintend those under him sufficiently to give more consistent decorative treatment to his own structure.

Mr. JOHN D. CRACE, Contributing Visitor.—It is with some diffidence that I rise to speak on a matter of construction, but the criticisms of the last speaker induce me to offer one or two remarks. I had the good fortune to be the first person to whom Mr. Scott Russell confided his theory of the iron cone, and in an amateur capacity I drew out for Mr. Russell such plans as he had conceived. The principle on which Mr. Russell proceeded was entirely one of making his construction consistent with what was outwardly shown, and what was outwardly shown consistent with the construction; and the first design, drawn by myself and submitted by Mr. Russell at Vienna, showed a façade entirely constructional, and from which plaster and stucco were absent. The whole project on which the design was founded was one of brick and stone supporting an iron cone, and connected with it. So much for the objection that the present construction is more or less a sham. Certainly the view presented by the substructure of the dome is actually sham, but that is apart from the subject of Mr. Russell's paper. Reverting to the cone itself, I have no doubt Mr. Russell, when he replies, will notice the suggestion made by Professor Kerr as to introducing a curve into the vertical girders of the cone. On that he will no doubt reply what occurs to me. Immediately upon the introduction of the curve into the vertical girder of the cone you introduce the very antagonism of two forces which Mr. Russell has set himself to avoid—viz., making the same part of the structure subject to the forces of tension on one side and compression on the other. Directly the curve is introduced you cease to bring the whole strength of the iron into play, but you divide the strength of the girder into two distinct tendencies. With respect to the alteration in the title of the paper suggested by Mr. Curzon—viz. "The new great problem" and "The old, old story," I would say that the Vienna cone rather suggests the title of the "The old, old problem" and "The great new story."

Mr. R. BELL, Fellow.—The point which I want to understand is this:—Mr. Russell says this circle is composed of thirty-two columns, and that he could remove from one to three or four of the columns without doing any harm to the cone; in fact he led one to believe that he could take nearly all the columns out, and nevertheless the cone would stand. That is something we never heard of before. I should like to have my ideas cleared up on the subject, because it is carrying his notions to that extent that at last of all we shall be able to build upon nothing at all, or have some support to begin with, then take all the rest away. I should like to know where I am wrong, for Mr. Russell could never have meant that, and I should be obliged to him to explain how far I am wrong in so interpreting his views.

Mr. PENROSE, Fellow.—I will confine my remarks to the point on which Professor Kerr has invited me to speak—namely, the catenaries. It is very difficult to apply the theory of the *pure* catenary to any structure. The notion is that because a chain when suspended will fall in a certain definite curve, and, with its component parts in tension, take the true line of the strain, if you could reverse the figure and elevate the chain it would stand with its component parts in compression. The mechanical problem has been tried, and I believe with some amount of success. By a suitable management of the links it has been found possible to reverse and elevate to a considerable angle a chain lying freely upon a smooth board. But in practice any arch built up of blocks must have a sensible thickness, and the pressures which would form the pure catenary are mixed up with friction and other pressures, and are considerably modified. Another circumstance connected with the catenary is this: Suppose (illust.) this came to be a pure catenary, and that the weight of the chain itself is not considerable. The moment you attach weight to the chain it takes another shape altogether. Thus the conditions of the pure catenary do not exist in practice in any arch. But in almost any arch that could be built you could imagine a catenary of which the figure has been altered by its being loaded to a greater or less degree, which should be within the structure, and if this could represent all the pressures and cohesions that the arch is subject to it would stand or fall according as such possible catenary may or may not lie within the voussoirs of the arch—but it would not be the pure catenary. The catenary itself is a troublesome curve. Its equation or formula is very complicated, and it is therefore an awkward thing to draw accurately unless one simply hangs a chain. [Professor KERR.—You can do it easily by parallelograms of forces.] I will add an observation on the shape of the cone. I believe the best possible form, if Mr. Russell will allow it, would be to give the sides of the cone the almost imperceptible entasis which is given in Greek columns, so that there should be a small amount of curvature to help the inclined line, and just to compensate the tendency to flexure in the material from its own weight, but any such entasis or swelling in the centre must be very slight indeed, so as still to satisfy the eye that the line is straight, and my impression is that if you are to have the line so straight as to fulfil the conditions of a cone, they had better appear to be quite straight than appear to be curved slightly. You would not get a grand form æsthetically without considerable curvature, and that would be bad structurally, because it would require bracing in some way, and so waste material. I can imagine, however, that accepting the principle of the straight line it would be desirable to give the side of the cone an amount of curvature which should be almost imperceptible to the eye, but still existing. With that exception I believe the straight line is best structurally, and unless you come to considerable waste of material, best æsthetically.

Mr. SCOTT RUSSELL in reply upon the discussion said: I shall be happy to give any explanations that will be of the least use in reconciling the members of this Institute to anything like my cone; but I must in the first instance explain to you, that almost any one of the points which have been raised now I should have gone fully into, and have replied to everyone of the most proper objections that have been brought—most proper, and many of which I entirely agree with, had it not been necessary to keep my paper within certain limits, and as necessary to use as little of your time as possible. I will now endeavour to answer the points on which you have asked for information as concisely as I can. I am afraid when I say anything it may have the appearance of being too dogmatic, but I hope you will not accept it in that way. I feel deeply grateful to gentlemen who have deduced the points and exceptions, and difficulties which they have done, because in answering them, I think I shall give them the conviction that the cone possesses greater merit than I could have satisfied them it possessed if they had not been good enough to make these objections. I will now run through the matter as quickly as I can. In the first place, permit me to say, that almost every one of the suggestions you have made, as to the alteration of the cone and the different views of its theory, are perfectly true; and allow me also to say, I have confined myself in that article to the pure cone, because if I had gone out of the pure cone into the region of new structures the quantity I could have laid before you is so enormous, that you would have been lost in a maze of confusion, as I was, and I had enormous difficulty in selecting out of the multitude of applications of principles of this kind, the form of the cone at Vienna. You would imagine men of taste would be in love with the beautiful spheroidal form, and would not take the strictly straight cone when they might have the more beautiful spheroidal form. I will tell you how I came not to adopt it, I drew it out and discussed its peculiar qualities, and it was only the peculiar state of conditions which led me to adopt this form, which I think, is not so beautiful as if I had made it spheriodal. A multitude of questions arose. It has been properly said, that time is a great element in practical construction, and engineers and architects are often obliged to abandon what they wish to do by want of time. Now want of time and want of money, are two things against the spheroidal dome. I will tell you why. The conical form has enormous advantages in construction. All the iron plates are plates of single curvature—straight one way, gently curved the other. What is the consequence? We can put them between rollers, we can manufacture them by hundreds and bring them out ready for the building. Take a surface of double curvature; you have to heat it in the fire, you have to cut its edges to a peculiar surface, you probably encounter great difficulty requiring much time to surmount, and if you have to do it, it is always badly done; whereas, my cone can be manufactured by machinery, on the most simple, but still most perfect mathematical principles. The reason why I prefer an absolutely straight cone to the cone with curvature is this: Mr. Penrose has touched upon the point. I have shewn you that all my cone longitudinally is in compression—that all my cone circular-ways is in tension. Now a straight column under compression, is much stronger than a bent column, and therefore, that part of the cone in compression is far stronger if it is straight. The next point has been very properly stated, viz.—that the ribs of this cone are very much deeper than you would imagine, from investigation of the cone itself. You are correct. The ribs of the cone, as originally designed, were much shallower than they are now. Why were they altered? Simply for the reason, Mr. Crace has stated, that all the conditions of the original design were altered. The cone was made for being put upon masonry or brickwork, which was to have been carried out to the edge of the cone, and the cone was to have been set upon that. Then the chance of the cone changing its form was very small, and these ribs or rings which have a peculiar function with reference to columns had no such functions when resting on masonry, and therefore were very small. These girders were enlarged, because it was agreed from circumstances of time, to sweep away the whole of the solid foundation; and one fine morning I was told, "you are not to have a wall to put the cone upon; therefore, you must stick it upon iron columns in the best way you can." Then to arrange the iron columns to carry the buildings, but to carry the cone, and that resting upon solid masonry foundations, are two things totally and entirely distinct. To sum up the whole question with regard to cone and girder, permit me to say, that these girders were by some people thought very strong when they were put up. Only there came a little wind after they were put up, and people who went there saw a slight vibration in the wind which satisfied them that the girders must come down if the weather were at all tempestuous. It was only after they got the cone to rest upon, that they became part of the cone. It was only then they acquired any strength at all. What they have is great strength in their place: out of their connection with the cone have they none. If you take the great thickness of the girder which is more than double what was designed, and then look at the length of it—166 ft., and then if you take the depth, not at the extreme end, but at the centre of gravity, where the strength is, you will find that these beams which you think strong are hopelessly weak to carry any structure, and then you will see that the beams had no strength till they became a part of the building. Coming more to the question of cones made of homogeneous metal, I may state that about three years before the opening of the Exhibition of 1851, I discovered that the cone was the successful structure which I have endeavoured to shew you it is; and it is a curious fact, that I owe to you, and the reception which you gave to me in some papers I read, the original ideas of this cone.

I read to you some thirty years ago a paper, describing a principle by means of which the greatest number of spectators could be arranged in a large building, so that they should all equally well see any spectacle they were brought together to see. I then, I dare say, satisfied you that you could make a building in which 10,000, 20,000 or 100,000 people could have sat together, all witnessing the same spectacle, and each one thinking he had got the best place in the room. That was solving a difficult problem, but it was leading you on to the construction of very large buildings with very large audiences. Twenty-five years ago I read you another paper, which you discussed with the same friendly energy as you have this, viz —on the question how to combine the largest number of people in a building, so arranged that all sounds should reach the ears of those present in the most perfect and distinct manner. I also tried to explain certain principles by which echoes and influences which impede sound, and impede the clear hearing of separate sounds, might be removed. I hope I persuaded you that a building could be made in which 5,000 people could comfortably listen to a single speaker, or an audience of 25,000 people could comfortably and agreeably hear a musical performance, but at the same time I know you did not believe that such buildings were necessary. But such buildings now have become so. You have had the Exhibition building of 1851, in which 100,000 persons were collected at one time, and you have had arrangements for the performances of music by orchestras of 3,000 persons, which have been listened to by 25,000 persons. [Mr. COOKE.—You cannot hear.] I have a deaf ear, but I could hear comfortably with my deaf ear; and the orchestra which you have now in the Crystal Palace has carried out in the most perfect manner the theory I then gave you. I call attention to this theory of seeing and hearing because it compelled me to think how I should roof this large building, and thinking over the problem you discussed, I arrived at this fact, "that if you are to have large ampitheatres to hold many thousands of people to view spectacles in London, in the way that the Romans did, you must make them with a cone, and I have invented this cone to cover your great buildings when you are pleased to build them, and if you make those great buildings in London—and you will have to do it, for buildings are growing larger every day—I expect you young men here will have to make roofs, not of 360 feet span but of 720 feet, conical roofs, and after that you will go on to make them 1080 feet, and perhaps you will not go farther in your lifetime, but I undertake to say the task will be easy, and the cost what in those days will be called moderate."

Coming now to this small cone. The moment the idea had not only occurred to me, but was proved by investigation to be an idea in which you could use material much more economically than any other form I knew, I immediately developed the other form of cone to which you alluded. I saw that in my kind of building it would be possible to cut away all the dead matter of the cone, and put it into skeleton; and many years ago, in conjunction with an eminent member of your own profession, I designed a building in which all you have said was done: in which we threw away the entire homogeneous cone, in which we take away those *trusses* of which you speak, which are as old as wood construction. I have seen in the Rhenish countries the cone with wooden roofs applied to those semicircular Romanesque buildings, which for a time on the Rhine were competitors with gothic architecture. I think I have seen wooden cones 250 feet in diameter. In like manner you use iron girders, and do what you cannot with wooden struts, and you make a truss which requires no useless beams, no wasteful doubling, which is a perfect cone like my homogeneous cone, but I have always called that a skeleton cone; and, therefore, when you get these two circumstances together, if you are wise you use a homogeneous cone for all it is good for, and a skeleton cone for all it is not good for: as it is not where columns are inserted below; and, therefore, you add these additional struts at the point where the local strain requires it. If you construct a cone with large foundations and continuous walls you find a solid, homogeneous cone is the cheapest and strongest form. If you make it on a small scale, where enormous strength is not required, you find the skeleton cone will answer all your purposes, and you can fill in with glass or any material you like. I like a homogeneous cone for this reason,—there is not one atom of waste. In common roofs you have slates and wood. The slates and wood do not carry themselves but are a burden upon the structure. I have a large cone which justifies the use of iron plates, a half or three quarters of an inch in thickness. I take these plates and form a roof of them alone, and then we have only to rivet and caulk the cone properly: and I believe it would stand without repairs for 100 years, and with repairs for 200 years; but you can modify this to any extent, and yet preserve to a large extent the principle of the cone. A gentleman mentioned the Exhibition of 1851 as having an iron dome proposed for it. You may remember that in 1851 many architects and engineers met and designed a building for the Exhibition. That was somehow eclipsed by Sir Joseph Paxton's wonderful invention, but allow me to say that a spherical dome can only be truthfully made by making curves of double curvature to every plate, and there is no difficulty except that you have to put your plates individually into the fire, and have them all hammered into ultimate shape. But I will show you a way of converting my cone into a dome at once, which was the very thing proposed in 1851. I would have built my cone in 1851, I had it all ready then. The cone I had ready was 400 feet diameter. Why did I not? For this reason—It happened I was one of the four persons who with Prince Albert originated the Exhibition of 1851. He insisted that I should be his secretary, and that I should be charged with the whole details of the Royal Commission. I had instantly to put all my plans into my pocket. I willingly assisted Sir Joseph Paxton to bring forward his. I told Mr. Henderson, Mr. Fergusson and Capt. Fowke all about it, and they kept my secret, and nobody spoke about the cone till after Mr. Crace had prepared my designs for the Vienna Dome.

About cones. I am glad to see the drawings of the cone which was then designed. That dome is what I would call a skeleton dome. First of all, I will show you an ugly dome, which I would [illustrating on board] make with a series of cones. If I were obliged to make a dome and were ordered to make an ugly one, but retain, if possible, the same principle and the same economy, which belong to my present dome, I would do it, without incurring the difficulty of double curvature, in this way, by uniting a succession of cones of increasing taper. I should thus make what people call a dome. That you see is very ugly; but if I wanted to reduce the ugliness of it, then I could reconcile these patches by a filling of wood or other material, and thus I should have got a cone which, geometrically speaking, one would call perfect and beautiful. Now, in like manner, I was delighted when Professor Kerr suggested that we might have a great number of buildings of that sort, and ever since I studied the cone I have been astonished at the small number of buildings of that sort which exist. I am astonished to see in your buildings and in ours, the waste of material you go to, when you might do without it. Suppose this to be an enormous square building; suppose you wanted to cover this with a roof. Why not make a parabolic roof? Make it a cone with four flat sides. Make it an octagonal cone, which you could do by cutting off the corners and putting in girders. Then you have no occasion for ties. Captain Fowke did that in some of his beautiful buildings at Kensington. You can make a series of structures, all self-contained, all without waste of material, and all under certain circumstances beautiful. Gentlemen have alluded to oval buildings. You find them immensely disposed to change their form, but there are remedies which consist of addition of material. You must put in material to counteract that tendency to change of form. I will now tell you a secret, which I am sure you will keep confidential, and not allow it to go out of these walls. It was proposed to me, once upon a time, to put a conical roof over the ancient amphitheatre at Rome. That would have been an architectural desecration. I went to a friend, who was an architect, and asked him, "What would you advise? I do not like to refuse these people. I am fond of the cone, and I should like to see it carried out: but would it not be a barbarism?" My friend replied, "Don't do it." I wrote back that I would not do it; but I had gone into the calculation, and I found there would have been no difficulty in putting up a cone, moderately expensive, which would have preserved the building for 200 or 300 years.

A gentleman asked me to-night whether I would like to take away all the columns, or a few of the columns in the Vienna building, and some of my friends have asked how the building is supported. I introduce that as an illustration of the difficulties I had to contend with. I was informed that my solid walls were to be taken away, and that I was to put my cone upon a series of iron columns. I was aware that they would press upon the margin of the dome very much. I did not expect the slabs of concrete put into the gravel of the Danube, to give way; but as earthquakes have taken place there, I argued the possibility of another earthquake happening after my crack building was put up. So I tried to make my cone stand even without continuous walls and foundations, and even in case of an earthquake coming. I considered what would happen if one foundation of a column gave way. "Very well," thought I, "if one foundation gives way, what must I do? I must carry the edge of the cone on the two adjacent columns, otherwise it will sway, and come down." Therefore, I have put a strong rib all round the edge carrying the cone from one column to another. But two columns might have given way. When two or three columns give way, this beam becomes too long to carry the columns. What must I do? I have only to keep a good thickness of metal in the cone itself, and then I should be extremely near having a catenary, that is, it is in one case a stretched chain. Take the case of three columns giving way. You will ask me, if three columns gave way, what will carry the cone above them? Professor Kerr did not like my terming the catenary an inverted arch. I do not think that is very strong But it is not that which carries my columns. Think of the position. Three columns are taken away. Remember, the three corresponding columns on the opposite side are not taken away; therefore there is the weight of the cone on the other side balancing the preponderating weight on this side, and all united together by the catenary surface, out of which you can make any number of links you like. The chain is there, and this catenary I am now showing you, is the catenary or parabola which has the whole of these columns hanging on this side, and the corresponding ones balancing them.

I have one final word to say, and that is, we have exhibited in a railway station not far from where we now are, a combination of engineering talent, with architectural skill, which is seldom witnessed, and there is no doubt the St. Pancras Station with its roof of 220 feet span, and its noble frontage, is a model of which your profession and mine may be proud. Only I must remind you that, if you want to go further, if you want much larger spans, you would find that the circular ground plan has enormous advantages for a railway station, which no construction of railway stations hitherto appears to have had; and I recommend to your serious consideration the construction of a very large circular railway station with a domical roof. You will find it has enormous advantages, When you take the matter into consideration you will see if you are required to design very large buildings in London, such for instance as on the great embankment taken from the Thames, you will find a circular plan with a conical roof possesses infinite advantages, and if it were necessary to make buildings, such as railway stations, twice as long and broad, which I think would be foolish, but you must do it if your masters order it, all you have to do is to put two circular roofs alongside one another instead of one oval, and the two close alongside will be much stronger than one oval roof equal to the area of the two. If I have omitted to reply to any of the remarks you have been so kind as to make, I am sorry for it, but I feel that I ought not to trespass longer upon your time.

PROFESSOR KERR.—We have already, I believe, thanked Mr. Russell once, but I certainly think we owe him a second vote of thanks.

The PRESIDENT.—I am sure, Mr. Russell, we all unite with one voice and one heart in returning this vote of thanks to you, which appears to be a repetition of what was done in my absence. I can add little—indeed nothing—to what has been said, having had the great misfortune of being obliged to go to the north of England when you read your paper, and I do not feel it safe from what I have heard since to venture upon any remarks. I have been extremely pleased with what I have heard, from you and from others to-night, more especially with your reply. All I can say is we owe you our warmest thanks for coming here and laying before us a great fund of valuable ideas with regard to constructions of this kind, which we do from time to time think of, but which we have rarely such an opportunity as you have had of carrying into execution.

Mr. RUSSELL.—Allow me to put one point before you. I fancy you could not do it to-night, but you will confer upon me a great favour if on some future occasion you will permit me to be the vehicle of conveying some slight compliment from this Society of Architects to those Architects in Vienna who have co-operated with me in this work, and if you can say you appreciate the very beautiful design of this building as a whole, and which they erected under great difficulties, and carried out in an incredibly short time, I know, from what I have heard them say of British architects, it will gratify them very much.

The PRESIDENT.—Perhaps some gentleman who has visited Vienna will on a future occasion lay before us an architectural description of the building, in order to carry out what Mr. Russell has just suggested.

The discussion having thus been brought to a close, the Meeting adjourned.

Royal Institute of British Architects.

At the Ordinary General Meeting, held on Monday, the 23rd of March, 1874, Sir G. Gilbert Scott, R.A., President, in the Chair, the following Paper was read :—

ON GOVERNMENT ARCHITECTURE IN BENGAL.

By William H. White, Fellow.

While it is of constant remark in India that, at home, little attention is paid to its affairs, it is also maintained by many Anglo-Indians that travellers are " the curse of the country." But although the former regret, with justice, that little is known in England of the Empire which it is their business to rule, they seldom hesitate to fall foul of any rash visitor who dares to communicate unfavourable opinions he may form on a journey through the great dependency. Perhaps this is inevitable amongst an omnipotent aristocracy which has not long been accustomed to outside criticism. Unfortunately it is easy for the community criticised to fling back at the critics an isolated error, or a distorted fact, and thus cast doubt upon the accuracy of the whole critique, because the enormous area of Hindustan, the difficulty of verifying impressions, and the fact that what applies to one Presidency is often inapplicable to another, render absolute exactness on the part of the traveller a formidable task. To have lived exclusively in Calcutta or Bombay is likely to lead to very little knowledge of India proper, and to say that many of our countrymen, born in Bengal, and who have passed a large portion of their lives in it, have never cared to visit Delhi, Agra, or even Benares, is equivalent to saying that there are Scotchmen who have never seen London, and Londoners who have never set foot in Dublin. The opinions of such people are naturally as narrow as those of the general traveller are superficial ; yet even if the latter be disposed to disparage some of the imported institutions of the country, he is sure to be astonished at the gigantic nature of the labour assumed in the government of so vast a territory. An Englishman of sufficient experience to compare his own island with continental countries is necessarily a proud man ; but one who has also seen parts of India as it is to-day returns with increased pride and confidence in British honesty and capacity for rule. He may perhaps weigh in a mental balance Modern Britain and Ancient Rome, and waste a thought upon the time when Australians will be clambering over the remnants of Anglo-Indian palaces. But here he will do well to stop, especially if he be enabled to appreciate the present condition of building in Bengal ; and if he have seen, or heard of, the vast civil and military constructions which, since the mutiny, have sprung up in different parts of the country, some to succumb beneath their own rottenness and the spontaneous disruption of their walls, others to be condemned as uninhabitable by commissions specially charged to examine them. Public works in India are generally designed and executed by the Government. In Bengal, under the late Viceroy, the civil and military works were separated and placed under the charge of distinct bodies of officials ; but the reform has not been carried so far as to confine military engineers entirely to military works, or civil engineers exclusively to civil constructions. The military and civil engineers, composing the Department of Public Works, furnish India with public buildings, aqueducts, canals, tanks, fountains, railways, drains, roads, bridges, many scientific statistics, and much decorative art of every description. In money matters the Department has had, until lately, only to ask and have. In the science and art of architecture, as in the disastrous question of taste, it is still above control. Its organisation is so contrived as to be capable of undertaking a colossal public building, the decoration of a lady's boudoir, and the macadamisation of a road. It accepts the construction of a bridge or a tunnel, a thousand miles of road, rail, or canal with equal confidence; and each of its officers is expected to superintend, execute, or assist at, all or any of these varied works. That many of them sometimes fail is undeniable, but that the majority, like the rest of our countrymen in India, try to do their duty is equally undeniable. Nothing would be easier and nothing more useless than to hold up the Engineers of Bengal to professional ridicule; but an attack upon a Department of Public Works is the last resource of literary destitution. I shall describe simply what I saw and experienced, in the hope that others may learn the lesson that has been taught me; and others perhaps will tell whether the manufacture of Government architecture in Bengal assimilates in any way with that of Public Works at home.

There are few, I may almost say no, "practising architects," as we understand the phrase, in India. In Madras Mr. Chisholm, a Fellow of our Institute, is an Executive Engineer, styled by courtesy Architect to the Government of Madras; in Bombay Colonel Fuller, R.E., is a Superintending Engineer, styled by the same courtesy "Architectural Executive Engineer and Surveyor;" while Mr. Molecey, an Executive Engineer, Mr. Adams, and Mr. Stevens are Colonel Fuller's assistants. Of these, Mr. Chisholm is the only one privileged to accept private practice. In Bengal, unless an appointment has been expressly made during the last year, there is no Government architect. Both in Calcutta and Bombay there are men who, educated as architects and engineers, are now contractors; and in their premises one portion is allotted to the "architect," just as others are devoted to the smith, painter, and carpenter. The Government sometimes invite them to offer tenders for the erection of public buildings; but however much the higher authorities may favour the contract system, my short experience in Calcutta led me to perceive that the Department itself was opposed to it; and that a call for tenders was seldom intended to lead to serious results.

British rule in the Peninsula is directed by the Supreme Government, called the Government of India. Inferior to this are the Local Governments of Bengal, Bombay, Madras, the North-West Provinces, and the Punjab, which are presided over by Lieut.-Governors; while other territorial divisions, such as the Central Provinces, and Oude, are ruled by Chief Commissioners. In the Government of India is the chief branch of the Department of Public Works, at whose head, in 1872, was a Colonel of the Royal Artillery. He is the secretary and intermediary between the Lieutenant-Governors and the Viceroy for all the affairs of the Department. Each local government has its particular branch of the Department of Public Works: and, in Bengal, during my stay, a Civil Engineer officiated as secretary in the absence of the military holder of the post—an unprecedented circumstance. There is also, in Calcutta, a Mathematical Instrument Department, with another Colonel at its head; and, though it is said that only bad workmen complain of their tools, both civil and military engineers would be justified, to my mind, in attributing the avowed imperfections of their drawings to the terrible productions of that Department; the functions of which could be better performed by any one of the extensive stationery warehouses in Calcutta, and to all appearances at a less cost.

The Bengal Department of Public Works is presided over by a Chief Engineer. Under him are Superintending Engineers, who each control what is called a Circle; these Circles are cut up into

Divisions, over each of which is an Executive Engineer; and under each Executive Engineer is an Assistant-Engineer; under whom are Sub-Engineers, Clerks of Works, Foremen, &c.; while a host of natives complete the itinerary of departmental service.

The business of the Chief Engineer is necessarily general, as it comprises all Bengal. That of the Superintending Engineers consists of the verification of estimates, the examination of designs, and the supervision of all buildings and other works in course of execution within the Circles they control; that of the Executive Engineers is to make the designs and estimates, order the materials, execute the works, and pay for them; that of the Assistant Engineers is to prepare the drawings and make themselves generally useful both in the offices and on the works. The Sub-Engineers, Clerks of Works, and Foremen, do what is implied by their respective designations; and native workmen perform the manual labour required in building enterprises. To sum up roughly, the Assistant Engineer designs a building; the Executive Engineer builds it; thus the artistic portion of the work is made inferior to the mechanical part of it; the architect's functions are degraded below those of the builder—the latter being practically master of the position, since he is the official superior of the man who best understands the design. The Executive Engineer as master of the architect—his Assistant—controls, where as a builder he should be controlled; and he often "measures up" the work he himself builds. If a mistake happen to be made, whereby a wall is put in the wrong place, or built too high, or too thick, he is rarely called upon to alter it, because all such alterations must be effected at the Government expense. An Executive Engineer holds in his hand, as it were, the five orders of architecture, the building-materials, and the public cheque-book, together with almost despotic control over his Assistant Engineer, the foremen, and workmen. It is indirectly in his power to alter, condone error, and spend indiscriminately—he and his Assistant being the only people really conversant with the drawings of the building in course of erection, since the visits of the Superintending Engineer, immersed in other business, do not often bring much practical benefit to the work; and, as you can readily understand, it is easy for men of the greatest experience to lose themselves in the confusion of walls and arches if they have not an intimate and personal knowledge of the plans, sections, and elevations of a large building.

If, however, the Superintending Engineer made the design himself and really superintended the work, as the title he bears would seem to demand, the system would assume a more logical aspect. If he were rendered responsible, morally and pecuniarily, the system would enter, if not follow, the high road to perfection; but the virtue of "if" under such a hypothesis would involve much change and possibly the precipitated retirement of more than one high-placed official to whom seniority has been equivalent to promotion. The "general orders" are very precise about responsibility; and each engineer is understood to be responsible for his particular share of work; but it is difficult to define the limits of his share. The characteristic quality of all departments, regiments, and corporations generally, *esprit-de-corps*, renders it almost impossible; for where all are willing to take general blame none are likely to suffer individually. Indeed, to fix responsibility upon any particular officer under the system at present in vogue in Bengal would be a crying injustice, as the following illustrations will suffice to prove:—During the thirteen months I was in the service of the Bengal Government two large public buildings were commenced. The plans, sections, and elevations of one of them, with an approximate estimate, having been approved by the Lieut.-Governor, were sent by the Superintending Engineer of the Presidency Circle to an Executive Engineer, with orders to prepare an official estimate, and to commence the works without delay; at the same time he was cautioned as to the precarious nature of the soil, and ordered to make plans and sections of the necessary foundations, the footings of which were to be calculated as regards width and depth, according to the weight of wall they were intended to carry. The plans and sections of those foundations, with a careful estimate of their cost, were in due time sent to the Superintending Engineer, approved by the Chief, and returned to the Executive Engineer with orders to begin. Those foundations were barely completed before a change was necessitated by unexpected circumstances. The Executive Engineer who had given a great deal of conscientious labour to the study of them, and who was responsible for them, was suddenly dispatched to the charge of a Division distant one thousand miles from Calcutta; another was appointed to the post thus vacated, and the works proceeded. Now it is clear that if those foundations fail, as nearly all foundations have hitherto failed in Calcutta, the original Executive Engineer cannot be called to account, because his mantle of responsibility was transferred to the shoulders of the colleague who superseded him; while each of the many Executive Engineers who have doubtless continued, or will continue the works, can plead, in the event of the failure of any portion of them, that it is due to the foundations which their original predecessor executed. I must add, that the acknowledged architect of both those public buildings (compo structures of no merit whatsoever) was not allowed to visit them while they were in course of erection; but his visionary responsibility was borne by the Chief Engineer, who vacated his post almost immediately after they had reached their second story. Another illustration of the difficulty of defining responsibility and of the omnipotence of the heads of departments, is to be found in the New Imperial Museum, Calcutta, a building in the Italian style with "ornamental" French roofs, the original design for which was made by Mr. Granville, at that time Civil Architect of Bengal. Some of the floors of that building were designed to be arched and the passages vaulted. Soon after the works were commenced an order was issued to substitute iron girders in their place; and walls designed to receive continuous brick arches were weighted at intervals with enormous wrought iron girders. The obvious consequences followed, and the building is cracked and ruptured in many places; while the public, with little means of learning the truth, believe that the failure is due to the incompetency of the architect who, if I am not mistaken, has not seen the building since it emerged from the ground.

By imagining this repeated all over Hindustan you have the most gigantic system of manufacture ever carried out by any government in the world. As a system it would be feasible if educated men were as conversant with science and art as they are with orthography and grammar. That up to the present hour it has failed, no one, not even the Department itself, attempts to deny. Just as the great Clive, charged before a special committee with the misappropriation of plunder, replied with pardonable audacity:—"Mr. Chairman, at this moment I stand astonished at my own moderation;" so, with equal reason, an Indian engineer might turn round upon critics who enumerate his failures, and say:—"Gentlemen, I am astonished that there are not more of them." That it is impossible to reform the system without improving human nature in general, and British cultivation in particular, admits of little doubt. Adam Smith said of India:—"It is a very singular government in which every member of the administration wishes to get out of the country, and consequently to have done with the government as soon as he can; and to whose interest, the day after he has left it, and carried his whole fortune with him, it is perfectly indifferent though the whole country were swallowed up by an earthquake." This is as true to-day as it was in the great economist's time. The peculiar circumstances of British rule necessitate government by Departments; and a Department, as a man who knew India has said, is the paradise of mediocrity. A member of one to succeed must sink his individuality in the general organisation of the whole machine. Even if the authorities, seized with a determination to have educated architects at any price, were to induce some of the leading members of our Institute to spend a few years in Bengal, disorder would be followed by chaos. A professional man to be of use in a Department of Public Works must hold the position of a Superintending Engineer. But to attain that rank is the work of many years, which must be passed in India away often from everything which, at home, promotes the study and development of art and science. To expect that a large body of men, who are giving the best period of their lives to Oriental service, are to cede coveted places to professional engineers or architects, is beyond the bounds of possibility. The reform of public building rests with the Department itself. My own experience showed me that if a Superintending Engineer could combine the qualities of a first-rate architect and a first-rate engineer, together with the business acumen of an educated builder, and the arithmetical specialty of a first-class surveyor, if his constitution permitted him to spend a quarter of a century in India, and to regard his career there as something higher than a monetary speculation, he might perhaps succeed in erecting a few buildings worthy of British rule; but even if he accomplished so much he must be heroic enough to dispense with artistic appreciation; or, at least, be satisfied with the little that can be squeezed out of the traditional apathy of an Anglo-Indian population.

II.—Calcutta is a medley of stucco constructions, at once palatial and petty; dull in the brilliant setting of an Eastern sky; vulgar in the midst of dependent races to whom vulgarity is unknown. The streets are generally broad and the houses lofty, without, until lately, any excrescences to break a skyline monotonous from dilapidated balustrades, cornices, and copings. Before describing any existing buildings, I propose to consider, not what "style" is best suited to the country, but rather the requirements which it is absolutely necessary to satisfy; and the obstacles to constructive security, domestic comfort, and æsthetic excellence, against which it is necessary to contend. The engineer has to provide a dwelling in Asia for a superior class of Europeans, and it must recall the architecture of home. It must be composed of few and often inferior materials, built by native workmen, under the guidance of those whose interest in it if it be not official is speculative; and who, in either case, are generally devoid of the ambition which often actuates client, architect, and builder in this country.

Houses in Calcutta must be placed with regard to aspect, north and south; because during the hot season the only breeze, except when a periodical "north-wester" springs up, is from the south. The windows and doors of all the principal rooms must be wide and lofty, and most of the former must face the south; or some means must be contrived to obtain direct southern ventilation. Each bedroom must have a bath-room attached to it on the northern side; and as the bath-rooms are water-closets as well, private stairs must communicate with them from the garden or compound for the passage of low-caste natives specially employed to serve them—the system of drainage not being extended to private houses, and indeed, to only one or two of the new public buildings. Large staircases, passages, and antechambers are necessary on account of the number of native servants employed, two punkah-walahs being stationed outside, sometimes each room in a house, both night and morning, all through the hot and part of the rainy seasons. A verandah consisting of broad openings with slender piers or columns, is required to protect the east, west, and south sides of a building, and it should be deepest on the southern side—the south verandah being the principal living room for the members of a family while the sun is rising and after sunset, during at least six months in the year. A carriage porch must be attached to the entrance, and during eight hours of the day the inmates must be enabled to feel the largest possible amount of the external breeze without receiving the rays of the sun, or even a particle of its glare; because in India, light is heat, and one of the secrets of the Hindustani architects consisted of a successful method of obtaining light without heat—a method ignored or disregarded by Indian engineers.

The positive nature of the climate is antagonistic to European modes of architectural arrangement, both decorative and defensive. For seven months in the year a rain-water pipe is of little, if any use; for the other five it is in constant exercise. The Government have therefore forbidden its use in public buildings; and many and strange are the devices employed by the engineers to drain their roofs and terraces within the letter of the law. Cornices and ornaments intended to catch the play of sunlight are not adapted for the reception of continued rain; and stone, or cement, saturated during twenty out of the twenty-four hours, is often injured by the burning sun which bursts out between the showers. During the rains the public and private edifices of Calcutta present a piteous spectacle; and the damp, unwholesome odour which pervades them, the effect produced upon objects of apparel, upon paper, and all kinds of furniture, serves to shew that the precarious nature of Anglo-Indian existence is due in some measure to the buildings in which Europeans are compelled to dwell. The public offices, as well as the majority of private houses, are built without a basement story, or cellars; and a flat terrace-roof covers them. To be damp from beneath, from above, and from the four walls, is the normal condition of a dwelling-house in Calcutta, during at least four months in the year; while towards the close of the rainy season innumerable insects build nests under the verandahs and on the inside of the walls of bed and sitting-rooms. To close the windows or doors of any room for the space of a few hours even in the best houses, is to invite every odour with which ill-begotten moisture can pollute the nostrils.

The terrace-roof of an Indian metropolitan residence, is often a morning and evening retreat for many of its inhabitants. It might be made a "hanging garden" of the most charming description. Let me remind you that north-western India is essentially the land of the Kiosk and the Dome. The former is an exquisitely beautiful feature of indigenous architecture. It is a canopy, square, oblong, or polygonal in shape, in stone or marble (sometimes both), supported upon piers or columns, domed and shaded with overhanging stone or marble eaves. Some architect, with more or less reason, has lately erected two imitations of an Oriental kiosk on a building situated at the Middlesex foot of Blackfriars Bridge. If you have seen them, you can imagine the graceful originals grouped upon the housetops of an Eastern city, and will perceive at once how agreeable such retreats would be on summer nights and mornings, especially when protected by blinds or drapery of some kind. Yet, no engineer has yet attempted to adapt them to European use in India; and during my journey across that country, the only person I saw sitting beneath one—and one of a hideously debased description—was the Nawab of Oude, on the top of his residence in Lucknow. The construction of the dome at a period co-eval with our Middle Ages, seems to have been accomplished by Hindustani architects with peculiar *naïveté*. On the broad plain, ten miles long by six wide, which holds the ruined cities of Ancient Delhi there are numerous domes, large and small, some of which have already existed for six centuries; and if left undisturbed by men, they may remain for six centuries longer. How they were built has puzzled and still puzzles the world, or at least, that part of it which knows them. If any one as a boy, have put together a grotto with oyster shells, he may possibly divine the principle, or absence of principle, which directed their construction, and which enables them to stand without ties or buttresses,—inert, without "thrust" of any kind. Now, although in these days of free trade nothing need astonish any one, it is nevertheless surprising that, in a land where the simplest, most logical, and cheapest domes have been constructed by native workmen, it should be thought necessary to use an Italian or a French adaptation of one; and, more, that the erection of domes so imported and constructed of imported materials, should cause inquietude in the breasts of European engineers who sometimes frankly admit doubts whether their handicraft will stand or fall.

A want painfully experienced in Calcutta is a covered footway; every street in the capital ought to be lined with arcades or colonnades; and the foot-passengers and others, descending from carriages into shops or offices, protected by a covering similar to that of the Rue de Rivoli in Paris, or the old

Quadrant in London. It may seem extraordinary to advocate such a thing for an Eastern metropolis, but it is still more extraordinary to find that nothing of the sort exists in the European quarter of any Indian city.

The beautiful screens of perforated stone and marble, which abound in Hindustani buildings, are nowhere introduced in Indo-European architecture; yet the manner in which they were used at Agra, Delhi, and Ahmedabad, to counteract the rays of light and to receive light reflected upon adjoining walls, must be familiar to Indian engineers. It is true that in the present state of the communications the stone and marble quarries of the country are of comparatively little use, at least to Bengal. It is cheaper to import marble from England than to obtain it in India, unless of course it is required for the neighbourhood of a quarry. At the same time a cast iron grating of home manufacture is often preferred, because it is English, to a marble grille of native work; and simple Birmingham, which supplies the Hindus with both missionaries and idols, often sent out to them in the same ship, has firmer hold of Anglo-Indian sentiment than a dozen native cities, rich in art and innate artistic genius.

Among the building materials at the immediate disposal of engineers in Bengal are teak wood, brick, tile, excellent mortar, and *chunam* (this word is often applied generally to all kinds of plaster, mortar, and cement), which is a superior kind of *stuc*, and a cement, similar to that much used by the architects of Louis XIV., made of pounded brick. Iron, slate, terra cotta, plaster, and cements are easily imported; artificial stone is made in Bengal, and stone of the best description can be obtained within easy railway distance. But of these, wood is a prey to the white ants; brick and slate are conductors of heat, and iron is considerably influenced by it; plaster though a good non-conductor of heat is destroyed by damp; while ordinary cement cannot withstand rapid alternations of sun and rain. Though brick may be guaranteed from water by a coating of good cement the sun inevitably cracks the coating; and a crevice once made the rain penetrates between the cement and the wall, causing more injury to it than if it had never been cemented at all. Consequently "honest" brickwork with a little stone bond and a few stone string-courses, is the safest kind of wall for a Calcutta house; but on condition that the wall be built *double*—that is, with a hollow space between an external wall (say two bricks thick), and an internal one (say half a brick thick), the latter to be plastered or cemented, and both divisions to be connected at intervals with stone or slate slabs.

In a country where an absence of chimneys, kitchens inside the houses, gas fittings, &c., preclude danger from fire, naked iron can be used with impunity, and with no other protection than paint can afford—at least in the interior of a building. To employ it, however, in the construction of verandahs and roofs exposed to the sun, and to electric action, cannot be too categorically condemned.

The soil of Bengal is more treacherous than that of Holland, and the sands upon which Calcutta rests is the most treacherous portion of the Presidency. What sort of foundations, how deep or how broad, whether concrete or piles should be used, continue to remain uninteresting topics of speculation to the most experienced officials; and in a late yearly report to the Government of Bengal, the Secretary in the Department of Public Works is assumed to have declared that as the walls of every building yet erected in Calcutta were spontaneously disruptured, so all future works must share the same fate—a logical *non possumus* which seems to have been accepted with complacency by the Lieutenant-Governor. In such a soil, the surface of which is devoid of even a hillock and which resembles the muddy bed of a river, cellars and sunk storeys are impossible. It is not deemed advisable to use wooden piles, and though iron piles have been proposed they have never been tried for the foundations of public or private buildings. What is wanted in Calcutta is a platform on which to build—something upon which to balance a building. I would suggest, and it has probably been suggested before, the formation of a colossal table with four, six, twelve, or more legs, which should be deeply immersed in the sand. These legs might be cast iron tubes (say five feet in diameter) filled with rubbish and broken brick. Rolled iron girders tripled, secured together with wrought iron collars and the spaces between them filled with brick or concrete, could be placed upon these legs to form a frame, and strengthened by transverse girders. Brick arches or flat vaults could be turned between these girders; and, with the addition of concrete, the homogeneous top of a square or an oblong table formed, which would rest upon four, six, twelve, or more points of support. The superstructure would have to be built with due reference to these points; and the constructive skeleton would necessarily consist of four, six, twelve or more brick or stone piers of *equal weight;* while each floor would have to be put together with lighter girders and arches in a manner similar to the original platform. To complete the external walls the space between the piers might be filled up with iron frames for doors and windows, and concrete or cement blocks coated with glazed tiles; the wall thus formed would be supported upon the frame of the platform; while the internal partitions composed of hollow bricks would rest, wherever they happen to be necessary, upon the brick and concrete top of the table. It seems to me that such a description of building would balance itself; and I was presumptuous enough to propose such a mode of construction to a high building authority in Bengal. Though he was pleased to approve the notion of a table, such as I have just described, he said that it was difficult to get the authorities to sanction expenditure for work which they could not "see"—that the *dekhne kewaste,* or what a French contractor once contemptuously called *ce qui est bon à l'œil,* was the one thing for which it was possible to obtain funds—and so it results that public money is squandered for inartistic "show," and refused for the purpose of ensuring a scientific system of foundations, at least in Calcutta.

Of the public buildings lately erected in the Indian capital, the least inappropriate is the New Post Office, and the most incongruous the New High Court of Judicature. The former is a specimen of the "Modern European," the latter of the Anglicised Franco-Venetian-Gothic style. The original designs for both, which were very artistic, were made by Mr. Granville, to whom I have already alluded; but it is certain, that as far as the New High Court is concerned, he would refuse to father the bantling of which Bengal has been prematurely delivered. The Post Office is composed of huge Corinthian colonnades, the columns of which are built of brick, covered with cement, and a well shaped dome of iron and cemented brick; and the latter has the merit of representing externally its internal section. But a broad flight of steps projects in front of the columns, and a broad pavement in front of the steps, so that no European can enter the building on a summer day, except under shelter of an umbrella; nor, arrived on the threshold, can he find relief from sun or rain, even in the recesses of the porticos. That the High Court is a lamentable failure, as far as architecture goes, is nobody's fault; even the substance of mediæval art is obtained with difficulty from books and photographs, the spirit never; and books, few and imperfect, have necessarily been the only guide possessed by its numerous builders. The judges' entrances are devoid of carriage porches. It should be remembered that no European can walk with impunity in the streets of Calcutta while the sun is up, and the Bengal Government have lately interdicted the construction of such porches in public buildings. Upon a flat terrace-roof, which may be said to cover the whole building, have been placed at intervals colossaliron Mansard roofs, plated with corrugated iron, of a height sufficient to contain two lofty storys, but to which there is no access, not even an eyelet for ventilation. They are thus reservoirs of caloric, so to speak, possessing the additional inconvenience of being permeable to the rain, in constant action from the rays of the sun, and a source of chronic danger from electrical influences.

In designing buildings for India, some past architectural style must of course be accepted as a basis upon which to create and fit them for the actual necessities of an Anglo-Indian community. But to transfer the Gothic of Northern France, or England, or even of Northern Italy, to the banks of the Ganges, bears on its face the impress of absurdity. A Greek colonnade, and a Roman arcade, though they may have sufficed to protect the walls of temples and theatres from a European sun, are insufficient against an Indian one; for in Calcutta the spaces between columns and piers have to be partly filled up with wooden blinds or *persiennes*, and these have often to be supplemented with other contrivances to counteract heat. It seems to me that the architect who designs for India, ought to turn, or rather return, to the works of the 13th and 14th centuries at Delhi, and to some of the later native productions at Agra and Ahmedabad. The best specimens extant of indigenous architecture, are in the north-west of India, and its best period is identical with that of the mediæval architecture of north-western Europe. It is impossible to realise the beauties of the Hindustani school from photographs even of the best description, and no pictures I have yet seen give the true colour of its red sandstone buildings. Mr. Fergusson has described them as representing "one of the completed architectural styles of the world," and here I take leave to acknowledge, with other travellers, the debt I owe to him, for means of study and information concerning Hindustani monuments. But the illustrations published in his *History of Architecture*, though eminently useful and exact, are not sufficient for students, either European or Native. Both require measured plans, sections, and elevations, drawn to a large scale, of buildings such as those still remaining round the Kootub minar, themausoleum of Toghluk Shah, and many of the mosques and tombs in and around the Purana Kil'a, in the neighbourhood of Modern Delhi, magnificent remnants of the Pathan and Moghul dominations. A writer in a well known journal published in Calcutta, has drawn a parallel between European and Indian architecture of the last century. He says:—

> "Hindustani architecture, even when emasculated and depraved, was ever lovely whilst it remained untainted by European vulgarity and British vandalism. The epoch of Louis XIV., which, as Voltaire has justly shown, spread its demoralising influence over all nations, left untouched the new city of Shah-Jehanabad—the modern Delhi—whose noble mosque surpasses the Invalides of Paris, the best work of the elder Mansard, as much as that excels the buildings of the Jesuits throughout Europe. Any carefully-drawn parallel between the last creations of the Hindustani school and the miscellaneous assemblage of abortions, designed without taste, executed without principle, and belonging to no school whatsoever, which emanate from the dark age of Christendom—the eighteenth century—could have but one result; and that may be obtained by ordinary sightseers. Those who run may read. They have but to compare the more modern Hindustani buildings of the North-West with Keddlestone Hall, Derbyshire (of which Government House, Calcutta, is a sublime copy), Blenheim Palace, or Horace Walpole's villa at Strawberry Hill. Domed tombs, arched verandahs, houses, aye, palaces in stone and marble—the works of living men—attest that the Hindustani style, though intellectually degraded, still lives in native hearts. The spirit is willing, but the flesh is weak; and there is no one to point out to a dependent people the principles of construction, which, in the fourteenth century, guided the master-workmen of a free and noble craft." *

Government assistance is needed to obtain a scientific and useful knowledge of Hindustani architecture, and to encourage a just appreciation of it amongst Anglo-Indian officials. Englishmen are apt to regard everything "native" as necessarily inferior; and to forget that much of the atrocious taste conspicuous in Indian dwellings of the present day is due to the examples set by themselves and their predecessors, who, although they have given the country political institutions, have destroyed its artistic traditions, and introduced, to fill their place, imported art of a more than dubious complexion. Modern architecture in India ought to be based upon the examples left of the Hindustani style of the 13th and 14th centuries, which is only a variety of the style of mediæval Europe fitted to the necessities of Oriental life and the exigencies of an Eastern climate. Strange as it may appear to Indian engineers, every detail of architecture necessary to compose a logical, scientific, and artistic dwelling for Europeans in India is to be found in the country itself. Indian stone, brick, and tile glazed and unglazed, for the walls; Indian vaulting for the floors; Indian arcading and grilles for the verandahs; Indian covered balconies for window openings; Indian domes, terraces, and kiosks to compose the roofs; with Indian parapets and projecting eaves to shelter the façades from sun and rain. All these features, essentially Indian, are known to the ordinary archæologist. If they were used by the engineers, according to the recognised principles of Greek and mediæval art, with the common sense which usually distinguishes Englishmen in their daily pursuits, an Anglo-Indian method of rational construction could hardly fail to be engendered.

---

* The "Indian Observer," Feb. 1st, 1873.

III.—A condemnation of the Bengal Department of Public Works is to be found in the actual state of Government architecture in Bombay. Doubtless the existence in that Presidency of a rich Parsee community, and the fact of its chief city being the commercial capital of Hindustan, have contributed to the progress which has marked the construction of its Public Works during the last few years. Comparatively speaking, and mindful of the opportunities enjoyed by each, it seems to me that neither Paris nor Cairo have accomplished as much as Bombay in the same space of time. Not even the first-named city possesses a nobler range of buildings than are now to be seen on the Esplanade at Bombay; and no building among them is nobler than the New University, which, with the local assistance of Mr. Molecey, has just been erected from the designs of our distinguished and ubiquitous President.

There is a peculiar notion which has taken possession of many engineers—not in India alone—respecting the work of an architect. During my employment under the Chief Engineer of Bengal, I was sometimes ordered to "put architecture" to engineering work; and I think you will bear me out in saying—as I told the Chief—that if his "engineering" did not contain the essence of architecture no power on earth could ultimately add it. I have had occasion, more than once, to hear that constructive details, such as girders, stone lintels, brick walls and arches, are engineering specialties, and that the architect's work is limited to the coat of cement with which the façades of buildings are sometimes dressed. This fallacy is probably the origin of the many extraneous horrors with which engineers are often pleased to spoil their works. It is astonishing to reflect, as it has occurred to me to reflect upon the magnificent bridges at Delhi and Allahabad, on that over the Sone near Patna and the Nile at Cairo, at Saltash and other places in Europe, that men who can work such marvels should endorse tricks of so-called decoration which even speculative builders now refuse to employ. Some time ago, when in Oude, I examined a small girder bridge then just completed. It was beautiful in its simplicity, and the fact that it conveyed of its containing no portion which was not necessary to the well-being of the whole. Not satisfied with this, the engineer must needs have two immense pedestals at each end. They were four times the height of a man, they held nothing, and they contributed nothing to the construction of the bridge. They had been introduced as architectural features, and this is what they were:—Square in shape, of solid brick-work, with towards the summit a few bricks laid in projection, on which rested a piece of wood, which in its turn supported more projecting bricks. The rounds of excellent brick-work, seventy in number, had been converted, by means of cement, into the appearance of nine courses of inferior stone; on the lowest stone course an extra thickness of cement had been added to form a base; the last stone course but one from the top had been made into a cornice, of which the piece of wood formed the corona. Upon three faces of each pedestal a parallelogram of cement mouldings displayed the semblance of a wooden frame, the centre of which was filled with a counterfeit wooden panel metamorphosed, by means of paint, into a marble slab; and this is what is meant by the term "putting architecture to engineering."

The Anglo-Indian mode of life necessitated by the climate is not conducive to artistic excellence, nor to those "sedentary and within-door arts which require rather the finger than the arm." The Englishman fitted for India is necessarily "warlike," and Lord Bacon says that "all warlike people are a little idle, and love danger better than travail; neither must they be too much broken of it if they shall be preserved in vigour. Therefore it was great advantage in the ancient States of Sparta, Athens, Rome, and others, that they had the use of slaves which commonly did rid those manufactures." There are however no slaves under British rule, and the natives of India are equal before the law with those of this country. But if they were not physically inferior to Englishmen the latter would not be there. The career best suited to the educated classes of the Hindu and Mahomedan communities is a subject often discussed, and nothing in the difference between the Viceroy and the Lieutenant-Governor of Bengal is more marked than the advice each has given to native audiences. Sir George Campbell has advocated muscular exercises, horse riding, buggy driving, and I think even pig-sticking, in imitation of European manners. Lord Northbrook has advised the native youth to apply themselves to the pursuit of art and commerce, and the first speech he made in public after his arrival in Calcutta, was upon the subject of art. He then urged his hearers to study purely native examples of it in preference to those of European importation. There cannot be any reason why the Hindus of the present day should not achieve for the British the same architectural triumphs that their forefathers accomplished for the Mussulman Conqueror. All the Mahomedan buildings in the north-west of India are the works of Hindus; and that something of the artistic spirit of their predecessors still remains in the race is attested by more than one modern example of native architecture. It is declared that the Bengalee is bereft of the faintest trace of originality, and that as a copyist he is far inferior to the Chinaman. But it is necessary to be able to copy well before trying to invent. The Bengalee has not had the artistic opportunities of the peoples placed more directly under Pathan and Moghul influence; and it says much in his favour that he is a skilful copyist. More at least can be made of him than many of our countrymen seem willing to accomplish. While I was in Calcutta a few native students, five I think, who had passed an examination at the Presidency College, were sent to the Department of Public Works, to be ultimately converted into engineers. They were all good draughtsmen, and had already acquired the rudiments of architecture, much in the same way as they are learnt in the European schools of art. They were all utterly ignorant of even the existence of any style of indigenous architecture. The best one of them was placed under my charge. He was a polished young Hindu gentleman, whose English was irreproachable, and who, always conversing with his fellow students in our language, was pleased sometimes to appear ignorant of his own. One day to test his artistic ability I ordered him to copy, to three or four times the size, the engraving of an elaborate mediæval fountain, designed by Mr. Burges. He not only made a good copy of it, but added the extra spirit it is necessary to give to an enlarged drawing; and I sent it to the Chief Engineer with some little exultation. The Recording Angel knows that my intentions were good; but so horrified was authority, so convinced was it that an artist, especially a brown one, in the Department of Public Works was an anomaly that precedent could not justify nor practice initiate, that means were instantly devised for driving the evil spirit out of him; and before I left India I was informed, though I did not attempt to verify the information, that he had been sent to make bricks at one of the Government kilns! This is not the moment to discuss what it is, or, it is not necessary, for an architect to know; but it is as well to recollect that the Hindu is made of a very different fibre to the Englishman. To know how to manufacture bricks is undoubtedly useful, but the time required to learn how to *use* them properly is so considerable, that it may be questioned whether such elementary practical education is not sometimes overdone. It was once thought that to excel in our profession, a man ought to have "worked at the bench;" but division of labour is a distinguishing feature of modern existence. In the Hindu, to whom I have just alluded, there was the stuff to make an architect; to have set him at brick making, was to do too much or too little. To be logical, he should have been taught to make the straw before the bricks, and to extract the coal with which to bake them. It is true European engineers are sometimes called upon in India to manufacture bricks, but this is a phase of the system which is worthy the attention of reformers; because, though a thousand men could equally well make bricks, only one of them perhaps could be educated into an architect. An unqualified belief in the "practical," is a creed with which many of our countrymen are too happy to deceive themselves; and too many ignore the fact, that nothing practical has ever been accomplished, until theorists have expended a vast deal of time over its consideration. The labours of Colbert, in the seventeenth century, and of Adam Smith, in the eighteenth, rendered possible in the nineteenth the practical introduction of free trade. German armies would never have victoriously traversed France had they not been first marched in miniature upon a map. The study of the principles of architecture, little respected in Europe, is still less encouraged in Asia; and architects have some right to address engineers who, in Bengal at least, usurp their functions, and studiously ignore their existence. We are the elder community. On our side are all the books of Europe, on theirs, a library of statistics and official reports; on our side are the imperishable records of twenty centuries, on theirs, fifty years of disastrous experience. Our own destinies are linked with a higher branch of our common art, under a more developed social system; and the artistic future of England, retired from European dissensions, and entered upon the path of universal education, bids fair to be brilliant. It is not too much to ask the Indian Government to promote the study of native architecture amongst the inhabitants of Hindustan. Success in such a task, would not only afford a sentimental gratification, but it would practically assist an alien aristocracy; and perhaps it might hereafter be said, with justice, that of the many benefits conferred upon India by British rule, not the meanest was that one which enabled the East, whence Art sprang, to participate with the Western nations in the glory of its later achievements.

The moral to be elicited from the action of Government with regard to ourselves is worthy of professional consideration. Administrative, in place of individual, enterprise has been instituted; the original object of which was doubtless to make more use of the military engineers than had hitherto been possible—the argument that they are under the thumb of authority while the professional man is a free agent being conclusive; and in India the civil engineer in the employment of the State is amenable to the same strict discipline. Now the responsibility of both is divided amongst so many different officers and grades of officers as to be almost null. But is the responsibility of a "practising" architect defined by law? If a Department carries on a gigantic species of manufacture is the architect in extensive practice very much better than a professional manufacturer? An Executive Engineer performs the functions of an English builder, with the exception that the capital with which he works belongs to the country and not to himself. The duties of a Superintending Engineer assimilate to those of many London architects, but instead of his interest in a building being diametrically opposed to that of the builder, it is identically the same. He is in the same condition of life, often a personal friend and powerfully influenced by *esprit-de-corps*. On the other hand, the architect is usually a friend of his client, and sometimes a man of superior education to the builder he employs. It is a point of honour for him to husband his client's money, yet his temptation to spend it is greater than that of the official, since he is paid by commission on the outlay, while official salaries are fixed. A London architect may have ten buildings in progress in different parts of England, each under the charge of an assistant. Why may not a Superintending Engineer have ten buildings in Bengal, each under the charge of an Executive Engineer? The fruits of the Government system may be often bad, but it remains to be seen whether the cause of failure be in the system itself, or the peculiar conditions under which it is worked. The experience of the last few years suffices to prove that individual architects cannot hold their own in any part of India, and it is gradually becoming clear that even in England it is a task of difficulty to contend against official opposition and ill-will. With a very little trouble the profession, I think, might steal a march upon the administration. I have attempted to show, and circumstances support my conclusions, that a Department is virtually irresponsible. Therefore earnest endeavours ought to be used to get an architect's moral and pecuniary responsibility in all professional matters clearly and satisfactorily defined; and, if you will permit me to say so, no more important subject could be submitted to the consideration of the Conference of Architects, which is to be held this year in London, than that of the liabilities of a member of our profession—before the law.

THE PRESIDENT.—I hope this very talented and interesting paper will not be allowed to pass by without some discussion. Perhaps Mr. Roger Smith will favour us with some remarks.

Mr. T. ROGER SMITH, Fellow.—I have had some little acquaintance with India through having paid a short visit to Bombay. I do not know that I can add much to the information which Mr. White has so ably laid before us, for I had no opportunity of visiting Calcutta. The conditions at Bombay with regard to building materials and the arrangement of the houses are, to some extent, different from those at Calcutta. The climate of the former place is rather more favourable. There is an almost constant sea breeze, which makes it a place where buildings can be tolerated more European in their disposition than those which are necessary in Calcutta. The exceedingly bad foundations described as universal at Calcutta have not to be encountered in Bombay, but in other respects what Mr. White has told you about the one only is in the main true of the other, and I believe of the greater part of India. The works executed by Europeans are in the main Government works. No Englishman goes out to India to settle there as a colonist. He only goes there with the idea of making money in a short space of time, and coming back again. He cannot reside there long without injury to his health. He cannot marry and bring up a family there, because the children must be sent to England early in life. He is a bird of passage and an unsettled person, and consequently seldom attempts any building on his own account, and either for residence or business purposes occupies such premises as he can rent, and therefore the only buildings of importance met with are Government buildings, such as barracks, and buildings of a higher class for official and public purposes. These are the buildings which are turned over to the departments of which we have heard of to-night, to design and execute; and undoubtedly a very anomalous and unsatisfactory state of things is the result. It is the theory that every engineering officer is able to do anything which any engineer can be called upon to do, and to a certain extent it is necessary to proceed on such an assumption, inasmuch as at any hour of the day an engineer may have a sunstroke and be laid aside, and obliged to go home by the next mail, and some one else has to step at once into his shoes, and take up his work where he left it. Under these circumstances it is difficult to see how these works, especially in the first instance, could have been carried out, except by very profuse expenditure, and, to a certain extent, under the lax superintendence of a department organised on such principles as these; but that there is immense room for improvement no one acquainted with India can doubt. To a certain extent some change for the better was attempted and has been made in Bombay. Sir Bartle Frere, at the time he was Governor, made the endeavour to induce English architects to go out to India and take part in the erection of certain large buildings, for which funds were available during his government. He obtained designs from a number of architects in this country, but the greatest difficulty was encountered in getting those designs carried out. There was a strong wish on the part of those associated with Sir Bartle Frere to make arrangements for introducing the contract system, and one or two buildings were erected by Parsee contractors in Bombay, but the majority of the works carried out from the designs of English architects have been carried out under the departmental fashion which has been described by Mr. White, and in some cases I fear the fathers of those works would be horrified at seeing their own children, considering that such details as were wanted had to be procured on the spot. In several instances works thus designed were carried out in Bombay under the superintendence of Mr. Molecey, who has been elected a Fellow to-night, and who has brought a cultivated taste and the fruits of a regular architectural education to bear on these works. It would be interesting if Mr. White would tell us the actual standing of those whom he terms "civil architects," as it is a status which I did not meet with in Bombay. The moral of the whole thing is that if you have to design work for India, unless for a railway company or for private enterprise, you may take it for granted that the execution of them will be placed in the hands of executive engineers, and therefore the path of wisdom will be to send all the details and instructions required, cut and dried, to make all as simple and plain as possible, and leave nothing on which any question need be asked. I need hardly say, notwithstanding what we have heard about refined architecture in India, rude workmanship and difficult materials have to be provided. I am sorry to be obliged to differ from Mr. White in his advocacy of Hindoo architecture. Before another Society I have lately advocated a different view at length. I may be allowed here to say briefly, that it seems doubtful to me whether a band of foreign conquerers like ourselves, occupying the country by force, and with prejudices of the most intensely un-Indian character, are warranted in attempting to revive a style of architecture which is in itself most un-European, and completely dissociated from any of our artistic instincts. My impression is that an European architect, in designing buildings for India, whilst consulting Mahomedan or Hindoo buildings for the means of sheltering the occupants from the heat, will fail if he wishes to take those buildings as his model. It is hopeless to attempt to infuse into our minds the feeling or the sentiment of the architecture of the country, and it is hopeless to expect to get it reproduced by the native workmen from our drawings. The best course, in my opinion, is to consult the styles which have grown up in some of the hottest parts of Europe, say the south of Italy, and take those for our examples, remembering that we have an intense sun-light to deal with, and an intensely powerful heat to exclude.

Mr. R. P. Spiers.—I beg to differ from Mr. Roger Smith as to the impossibility of employing the Indian style of architecture in future buildings. Last year I was requested to undertake the superintendence of a series of working drawings for two public buildings in India. They were designed by a government engineer, who was obliged to come to England on account of his health, and wished to have the working drawings made here, and sent over to be carried out by the executive there. When I was asked to undertake the work, I supposed that whatever sketch or design would be brought to me would be of that extremely unsatisfactory character, as regards style, to which Mr. White has alluded; but I was agreeably surprised to find a design, which, with as far as my knowledge of Indian work went, seemed to me as good as the representations I had seen of Indian work whether in photographs or in books. It would seem these drawings were made by native artists from the designs of this engineer, who had travelled fairly over the country, and had obtained photographs of all the old buildings, and in the combinations which he made, he endeavoured to reproduce generally the principle of design of the old buildings. The drawings submitted to me were those for a high school, and a high court of justice. In those buildings there were arcades, with scalloped arches, verandahs with pierced stone balustrades, skilfully contrived ventilating roofs, and also, to crown the top of the building, those kiosks, to which Mr. White has alluded, and which served as decoration. They had also as prominent features those domes of which we see so many representations in Indian buildings. The working drawings were made here, but all we had to do was to copy the originals. In parts of the building there were complicated vaultings of the type of those in the Taj Mahal. For the execution of the vaulting, which was in brick, it was not necessary to make working drawings ; the $\frac{1}{8}$ inch scale drawings sufficed, for the native workmen knew better how to execute that work than if elaborate working drawings were prepared. The same may be said with regard to a great portion of the decoration. The engineer made half-a-dozen designs for the rosaces, and other decorative features, giving the general principle ; the others would be worked out by the native workmen, and moulded in plaster on the building itself. From what I have seen, it seems to me that if we could only turn it to account, the traditional style of Indian architecture could be carried out in the present day as much as that of other countries was done in the middle ages. It only requires to have engineers of a certain amount of intelligence and zeal, and a desire to improve the people, to introduce into India works which shall not have the character given them of being vulgar in the extreme. Therefore I do not agree with Mr. Roger Smith, that it is impossible to reproduce that architecture which was available in the 14th and 15th centuries. If engineers in India will take the trouble to obtain photographs, and study them carefully, they may, with a comparatively slight amount of architectural knowledge, design such buildings as are required by Indian people, in the same style. I believe the people of India are more enlightened in these matters than the government. The schools and courts of justice are generally very simple in plan, and do not contain all those conveniences which here in England are considered of first importance. They accord, however, perfectly with the wants and customs of the people. The rooms are large, lofty, and well ventilated, and I see no reason why the future architecture of India, managed even by Indians themselves, should not be of that character which would retain the principles, and to a certain extent the details of the architecture which prevailed in that country in the 14th century.

Mr. T. **Morris**, Associate.—The flood of humour Mr. White has thrown into his paper is likely to do good by pleasantly calling attention to an interesting subject; but we should not forget the earnestness of purpose evinced by the Imperial Government in effecting and promoting the grand series of public works which, more especially since the termination of the East India Company, have been executed in the Dominion. This rapid introduction of works of utility of all classes shows the Government to be intent in ameliorating the condition of that vast territory. As to the employment of officers of departments in architectural affairs, it seems to be done under more excusable circumstances than we are accustomed to witness at home, where it is far too commonly adopted without the plea of necessity. In India things are very different, and the Government has both to provide and apply the means of operation. But we may anticipate good results; experience and intelligence will create a sense of the appropriate, and thus prepare for an eventual overlaying of art.

Mr. C. F. **Hayward** proposed a vote of thanks to Mr. White for his paper, which having been seconded by Mr. J. Jennings—

The **President** said,—We are immensely indebted to Mr. White both for instruction and for amusement, if I may use so familiar a term, in bringing before us a most important subject, and a very difficult question. I had thought during the earlier portion of the paper it was a hopeless question : it seemed to be so entangled with difficulties from which there appeared no escape. In India we are as conquerors of a country in which we could not live more than a few years ; which nobody will visit for any length of time without some temptation of a lucrative or honorable character; in which no architect would venture to establish himself with the intention of spending a professional life; therefore, who is there who can erect works for us, the European conquerors and occupiers of that country? There is one set of men who are of necessity there. We *must* have an army there, and that army *must* have its staff of military engineers, and there is also in the employ of the Government a large band of *civil* engineers. It is, then, inevitable that the direction of works must be in a large measure in the hands of engineers. One would have expected that this being the case that body, trained as they are to scientific and practical study both as to materials and every other matter requiring practical knowledge, would make sure of providing for the special practical exigencies of the climate and country. To my astonishment, we hear from Mr. White that these are points in which they signally fail. It would not be surprising that they should fail in some things, just for instance, as in matters of taste; but we would hardly suppose them to fail on practical objects; yet it would appear that they not only fail in these themselves, but they forbid others to carry them out who wish to do so. That is so gross an absurdity that it only requires to be pointed out to be corrected. I have no doubt Mr. White's paper will be seen in India, and that something will be done to remedy this absurd state of things. But when we come to architecture itself it is different. I agree with Mr. White that it is not reasonable to carry into India a style of architecture, which is adapted for climate and circumstances wholly different, if not contradictory. But what can you do? As I have heard a member of the Government say at the dinner of the Institution of Civil Engineers the other night, in returning thanks for the House of Commons, " We do not pretend to be very modest, but if you do not like us, why did you elect us?" We likewise say, " If they do not like our style of building, why do they come to us for designs?" But I think the case has been met by Mr. Spiers. English architects ought not of necessity to be employed in India. The great thing is to cultivate the existing style of the country, and I rejoice to find not only that Mr. White advocates it, but that Mr. Spiers has shown it is absolutely practicable. It is of no use for an architect to attempt to carry out a style in the midst of which he has not been born and bred. In Italy the architect makes his designs, whether mediæval or in the antique style, from the study of the works he sees around him, and he designs in the style of his forefathers. In England, in whatever style you work, you have around you examples—original mediæval examples and classic at second hand, and if you cannot carry out works of similar style, it is your own fault. But for us, us English architects, to attempt to carry out Indian architecture is absurd. We have never seen it, and it is only from prints and photographs that we know anything at all of it; while the books on it, excellent as they are, give no details. The only course is to educate a band of Indian architects to carry out their own wonderful, and still living style; and if, as suggested by Mr. White and Mr. Spiers, the Government would take up that idea and form a school of architects thoroughly trained in their own architecture, I am persuaded in a short time they would rival the works of their forefathers, which we so much admire.*

The vote of thanks to Mr. White was unanimously agreed to, and the Meeting adjourned.

---

[*] The President wishes, in the above remarks, to be understood to refer rather to the *future* than the *present*; for, as there exists as yet no such organised staff of native architects, it would be premature to look for early results. What Mr. Spiers tells us, however, holds out hope that, if such a system were set a-foot, it would not be long in bearing fruit. Meanwhile, if European styles must be imported into India, our mediæval architecture is, to say the least, more allied to one of the two great branches of Indian architecture than is the case with the classic styles.

In dealing with *sacred* buildings, the case becomes more difficult. The two great Indian styles, considered from a religious point of view, are one Pagan, the other Mahomedan. Of the former, I would say nothing; but of the latter—which was, probably, chiefly alluded to by Mr. White and Mr. Spiers—one may say that it was, in its origin, derived from the Byzantine—the Christian architecture of the East—to which our Western styles are also largely indebted; it is a style of pointed arches, arcades and domes; and, just as the Christian inhabitants of Sicily re-Christianized the architecture of their Saracenic invaders, so may Indian Christians, whether native or European, re-Christianize the style which has been planted among them by amalgamating it with the purely Christian style of the European conquerors.

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 20th April, 1874, Sir G. Gilbert Scott, R.A., President, in the Chair, the following paper was read:—

ON THE OLD HALL AND NEW ASSIZE COURTS AT WINCHESTER.

By T. H. Wyatt, Fellow.

Gentlemen,

I have been asked by the Committee you have appointed to arrange papers for your meetings, to lay before you this evening some details of an important and interesting work on which I have lately been engaged at Winchester, viz., the restoration of the old Hall of Stephen's Castle and the erection of new Assize Courts for the county, in immediate connection with this old Hall. Useful as I think this class of paper may be, where there are any circumstances of special interest or novelty of construction, I should hardly have felt justified in acceding to their proposal and trespassing on your time, if I had not been able to combine with the description of a building without any very novel conditions, some details and discoveries of considerable antiquarian interest. This will not be surprising to those who remember the "Old Hall" at Winchester, and its celebrated "Round Table."

For the power of bringing this paper before you, I am indebted to the kindness and confidence of the Committee of Magistrates who were empowered to procure designs for the new Assize Courts, and who, without competition of any kind, did me the honour to seek my advice and recommend my plans for adoption by the Court of Quarter Sessions. They were approved, and, with such modifications from time to time as circumstances called for, have now been completed, and one Assize and two Sessions have been held in them. The new buildings I have erected adjoin and communicate with this ancient Hall; and on the removal of the old Courts, which were partitioned off at each end of the Hall, several features of considerable interest have been brought to light. In dwelling on the old Hall, I shall refer as briefly as I can to a very interesting and valuable paper by Sir Edward Smirke, a name familiar to us all. The Plan on the wall shows this Hall in its original and beautiful proportion; the one below it shows how the old Courts were partitioned off, the divisions running the whole height of the building and utterly destroying its beautiful form. There is a longitudinal section, and one across the Hall, showing its three divisions, corresponding with the nave and aisles of a church.

This old Hall was for many generations supposed to have been an ancient church or chapel. The late Dr. Milner (whose history of Winchester has been held in much repute), and other writers on this room and the adjoining Castle, such as Warton, Grose and others, have asserted without hesitation, "that the Hall, used for Assizes and Sessions, was an ancient church or chapel, and that the round table in the Hall was made by King Stephen." It remained for Sir Edward Smirke to set at rest so erroneous and so long current a belief. In a learned and elaborate essay on this point, read before the Archæological Institute at Winchester in 1846, this gentleman disposes of that theory in a manner that will, I think, be conclusive to all those who will take the trouble to refer to it. They will concur in his assertion that "no proof has ever yet been adduced that this structure (almost the only surviving relic of the ancient Castle at Winchester) was destined or has ever been applied to religious uses, and any eye moderately conversant with early architecture will easily convince himself that it never was destined for a church or chapel; and that the plan, arrangement and finishing within and without, all announce it to have been from the first a Hall."

In 1175 (21 Hen. 2), this "Aula Regis in Castro" was under repair; sufficiently attesting to its antiquity.

In 1220 (4 Hen. 3), the sheriff of Hants was ordered to prepare this Hall for the reception of the King.

In 1222 (6 Hen. 3) occurs the first of a series of accounts respecting the Hall, and from this time forth, there are abundant records of works undertaken for the repairs and adornment of this Hall.

In 1235 (19 Hen. 3), a new kitchen, buttery and "dispensa," were made on the north and south sides of this Hall (hence probably the doors at this end of the Hall, A and B on Plan).

In 1236 (20 Hen. 3), the capitals and wooden botilli in the beams of the Hall were gilt. The Hall itself painted and whitened; and a seat for the King was placed at the head of the Hall, "versus orientem;" glazed frames were made for the windows, and in the gable of the Hall, "versus orientem," was painted "a wheel of Fortune." These works of decoration were done by "Elias of Dereham," who may be taken as the architect of the Hall. He was the architect of the Early English Chapel (now the Garrison Church) at Portsmouth; the eastern windows of which are very like those of Winchester.

In 1238-9, the King issued special orders that a "Mappa Mundi" should be painted for the Hall.

In 1252 the Hall was repainted, and seven years later, in 1259, the picture was renovated.

I will not allude further to the records of works to the Hall in subsequent reigns, until we come to Richard II. and Henry VI. In the former reign there are three Rolls, and in the latter, six, showing considerable works to the roof, and *to the north and south walls of the Hall.* These probably have reference to the very important and interesting alterations made in the walls of the aisles and in the treatment of the roofs, to which I shall shortly have occasion to call your attention.

In the reign of Elizabeth, the corporation of Winchester repaired the middle roof of the Hall, and the Queen the south side.

The Castle remained for more than 500 years the property of the Crown. James I. bestowed it in fee-simple on Sir Benjamin Tichborne and his descendants, for faithful and devoted services which he, as High Sheriff, had rendered to the King on his accession.

In the "Great Rebellion" the Castle was garrisoned as a royal fortress, but subsequently taken by Oliver Cromwell, who, *more suo,* dismantled it and blew up the fortifications, happily leaving the Old Hall standing.

Sir William Waller whose sister was married to the real owner (Sir Richard Tichborne) obtained a grant of the Castle from the Parliament whose cause he espoused, and either this Sir William or his son sold the great Hall to certain Feoffees for the purpose of a Public Hall, for the County of Hants.

In 1659, and again in 1668 this Hall was repaired by order of Quarter Sessions. How it was occupied from that period until the two ends of the Hall were partitioned off, I do not know. I had been before that, the place in which the King's Commissions were held.

I have thus, gentlemen, traced this Hall from a very early period down to its having passed into the possession of the County; it seemed desireable to do so, to show what historical and antiquarian interest it possessed and what a privilege it has been to have to do with such a relic.

In addition to the claim on the interest of the architect which this Hall must have, there is ample food for the appetite of the antiquary in the consideration of the purposes and antiquity of the "Round Table," which was till lately suspended against the eastern wall of the Hall, but which I have found it necessary to remove to the western wall, its old position "*versus* orientem," if it has anything to do with the "wheel of Fortune" of Henry III., or with the "Mappa Mundi" of 1238.

Sir E. Smirke says: "In the beginning of the 16th century, and probably long before a round table was an appendage to the Hall. In the reigns of Henry VI. and Edward IV. Hardyng the poet who lived in both reigns, alludes to the table of *Arthur* as hanging yet in Winchester." Leaving antiquaries to settle the date of this table, and the conflicting opinions upon it, I think we may take Sir Edward Smirke's view of it to be a safe one; he says, "Whatever may be the date of this identical table and its paintings, there is reason to think that if it be not substantially one transmitted to us from the first renovation of the Hall by Henry III, it is at all events a table of ancient lineage, the surviving representative of a very venerable work of art, which once occupied its place, with some allowance for repaintings and reparation, it is at all events impossible to deny to it an age of about four centuries, and it is probable that this may be extended to six, but the chances in the present state of the evidence are in favour of some early intermediate date."

Here are two fine photographs of this table, one of which at least is interesting, for most assuredly no one now living has seen the reverse side of this table, nor has any reliable representation of it been given. It will be seen that the original framing of the table took the form of a wheel, with twelve radiating ledges, or spokes, in each of which is a mortice hole to receive a tenon with two stout pins partly left in; that these could have served any other purpose than to receive legs on which the table would rest, seems utterly improbable; certainly they could have answered no purpose of suspension. In addition to these legs it may fairly be assumed that there was a central support. There are evidently two distinct dates of carpentry, the latter of which may probably be that alluded to under the item of "repairs." This table was only taken down from its eastern position at the last moment, when it became necessary to open the communication between the old Hall and the new buildings. I need hardly say that it was lowered and subsequently raised to its present resting place with the greatest care and anxiety to your humble servant, who felt that if an accident had happened, and the table been smashed, he would most assuredly have had to occupy one of the cells below, which he had just been building for prisoners on their trial; so great is the veneration in Hampshire and Winchester for this relic. Before it was again raised it was secured on the outer edge with a wrought iron hoop or band five inches wide, like the tyre of a wheel, securely key-wedged together, and this subject of a *questio vexata*, is now, I am happy to say, securely hung upon the western wall of the Hall.

By the kindness of Mr. Baigent, of Winchester, whose antiquarian information is well known, I am able to show an old print of the Hall, supposed by the costume to be about the reign of Queen Anne. The perspective of the table is somewhat bewildering, it is called "The east prospect of the County Hall, at Winchester." I venture to think that it is intended to represent the western wall of the Hall, as seen from the east end. The rude representation of a door in the right hand corner being intended for the early English one to which I shall refer presently, and the four openings over the gable under which the Judge presides, to the termination of a wooden tube which we have found in this western wall. If this view is correct, the round table, or Mappa Mundi, is in its original position, "*versus* Orientem."

It was not until the new Courts were sufficiently forward to admit of one of them being ready for the following Sessions and Assizes, that I was able to have removed the partitions and fittings of the old Courts in Hall, and to commence opening the communication between the old and the new work. This required a good deal of management and energy on the part of the builders and clerk of the works, and of forbearance on the part of all attending the first Sessions and Assizes. The eastern wall of the Hall and the old wall of Castle, which abut against each other, give a united thickness of about 9 ft. at one end and 6 ft. at the other to drive through, and this in flint work of the hardest kind required time and perseverance ; and as the Courts in the Old Hall had to be used up to the last moment, we were unable to begin removing the old roof of Hall and putting on the new one, until the opening and the new Courts were ready for work.

The new roof had become a necessity, for I found it in a sad state of decay ; and anxious as I was to re-insert one or more pairs of the rafters in the old roof as evidence and an authority for the form and scantlings adopted in the new roof, they were not able to find one pair sufficiently souud to re-introduce ; I am therefore only able to assert that both form and scantlings have been religiously adhered to. The plates of centre roof have been trussed (as shown on plan) instead of having a large flat plate in one piece.

On the removal of the partitions, floors and staircases of the Old Courts, (which had been built up with the most complete disregard of any adjoining architectural features), and on the removal of the plaster from the north and south walls, several points of interest presented themselves. I shall best describe them by referring to the general plan and then alluding to the details.

A. Doorway or recess in south wall, probably the door leadlng to a staircase, and to a gallery over.

B. Jamb of a small doorway under window in north wall, no doubt communicating with the kitchen, buttery and *dispensa* of 1235.

In the longitudinal section of the old Hall (by Mr. Carter in 1843) it will be observed that a second door is shewn under the easternmost window of the south wall. This would no doubt have communicated with the kitchen offices stated to have been built in 1235, both on the north and south sides of hall. For the sake of a most unsatisfactory uniformity, these doors were done away with on the north side, the entrance door made in the centre, and the two easternmost windows which were orginally shorter than the others, lengthened to correspond with the three at the western end of Hall. Mr. Carter is not responsible for this, seeing that he found the elevation of this north front disfigured in the hideous manner shewn on the drawing, as it appeared in 1843, but why he should have thought it necessary to get rid of the easternmost door shewn in his longitudinal section and to lengthen the window over it, I do not know. I presume he found them as shown in his section, which is not described as a restoration. It is much to be regretted that this change was made, and so much of the old character of the Hall lost sight of.

C. Jamb of a large doorway also in north wall, and immediately opposite the large one in south wall, this no doubt being the principal entrance on the north side.

D. Capital shewing the position of external column and jamb.

E. Base.

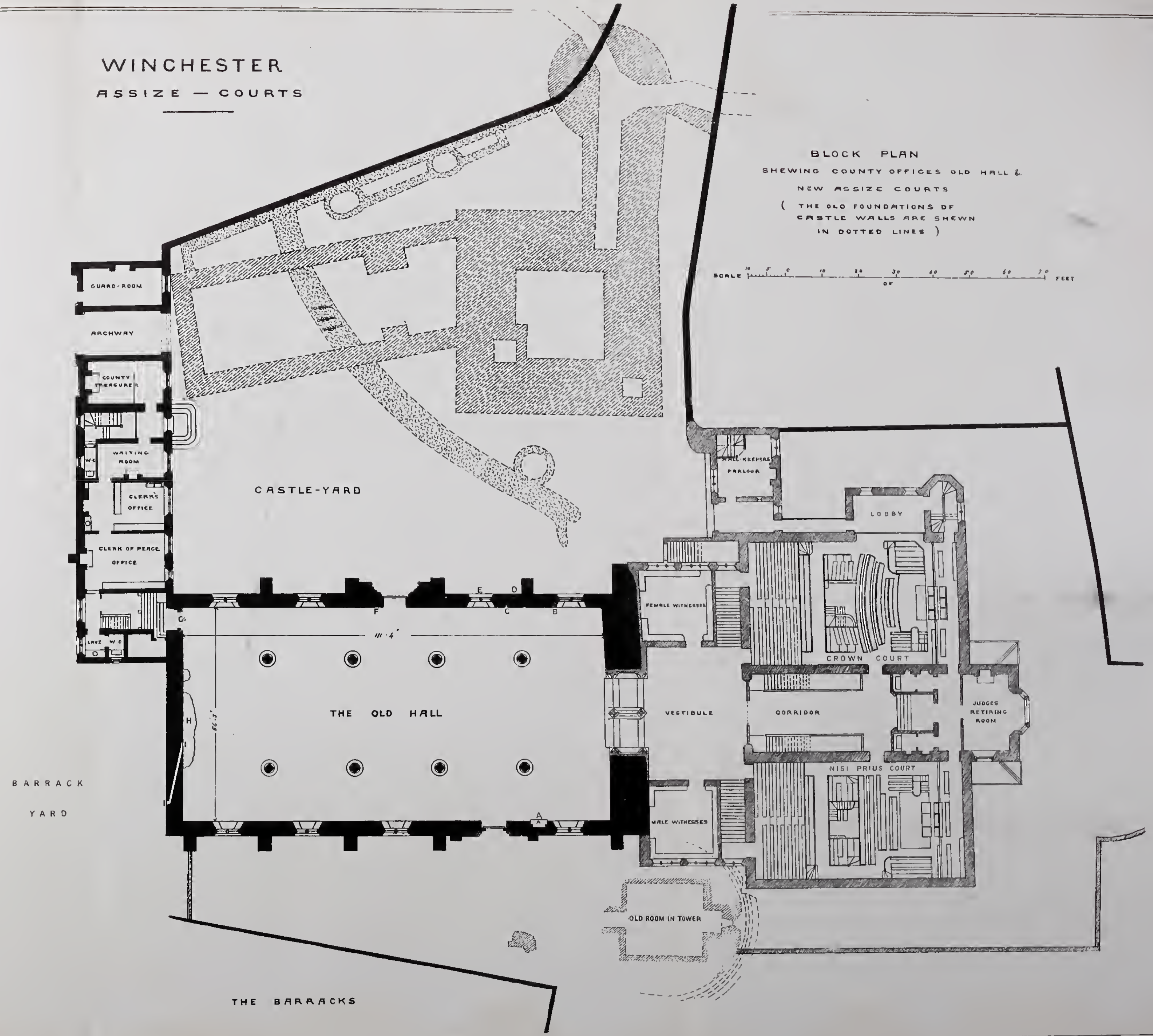
F. Shaft and jamb of former window, which was cut away when the centre doorway was formed.

G. Remains of an old and important doorway in the western wall of Hall. (Plan, elevation and section, with detail of mouldings, &c.)

This doorway evidently communicated with some important portion of the Castle, for the remains of old and massive walls were found beyond this doorway in excavating for a new strong room for County Deeds. One of which walls continues in a straight line with the south wall of Hall, and of equally massive dimensions. A heavy door must have hung here, judging by the substance of the iron hooks. We were aware of the existence of an early doorway in this position, for in cutting through the subterranean passage, which was done some years ago when the former cells were built, a part of a jamb had been exposed to view ; but it was a most agreeable surprise to find so important and interest-

WINCHESTER

ASSIZE — COURTS



ing a doorway in the very spot where it was wanted, and where, if this had not existed, I must have cut one through to form the means of communication between the new Courts and Hall, and the long range of County Offices which stand at right angles with the Hall at its western end. This doorway gives access to a new staircase leading to the Clerk of the Peace and other Offices on the ground floor, and to the Magistrates and Committee Rooms on the first floor.

H. An old foundation of rough masonry, about 3 ft. 9 above the floor of Hall, of somewhat irregular shape and rough material, but which may well be the lower portion of that seat for the King, which in the 20th year of Henry III. was placed at the head of the Hall "*versus* Orientem." This will be preserved in its present state, and be railed off as a matter of preservation. This bit of masonry had been protected by the floor of the Judges' Seat in the Old Court, which was immediately over it.

I. On the removal of the niche or woodwork at the west end of this Hall, a curious trough or tube of wood 8 in. by 6 in. was discovered running diagonally through the wall towards the south-west corner, terminating outwards as shown. The mouth or opening of this tube came nearly to the centre of the west wall, and was at a height of about 6 or 7 ft. above the level of the supposed dais or Royal Seat. What was the special purpose of this tube, or whether there are other examples of similar means of communication in antient Halls, I am not aware, but it is strange that it should run so far diagonally through a thick wall of flint; very difficult to have been introduced after the wall was built, and very curious if it formed part of the original structure. Could it have communicated with one of the Queen's apartments, and used to remind her lord and master that he had had enough to drink and was sitting up too late ?

On the south side internally no special or unexpected features present themselves. At the east and west end of the Hall, there were observable upon the plaster various bits of its antient coloured decoration, as shown on the accompanying full-size drawings (traced from the originals), the flowing ornament at the west end being in red and that at the east end in black. This decoration I hope we may be able to re-introduce ere long on the western wall at any rate.

But the most interesting discovery (if I may apply such a word to the result of examinations which these works have given us the opportunity of making) that I shall have to bring to your notice, consists in the undoubted fact that the aisle walls as now seen were not originally so built; but that they were low, the centre or nave roof being carried on in a continuous line until it met the north and south walls at this much lower level (as in the case of the old and interesting hospital at Chichester). In the Winchester case, the windows and circles over them standing out prominently as early and rare examples of dormers.

In the south elevation of the exterior, made by Mr. Stopher, the County Surveyor, in 1872, before I had commenced operations, it will be observed that on each side of each of the four windows there are small stone columns walled in, or at any rate, left standing. The caps and bases all range in level, and that between and above these columns, the face of the wall is finished with stone ashlar, instead of flint, as the rest of the work is, and that over the windows there are the lower half of a circle formed in the ashlar. Upon opening out at the base of one of these shafts, we found the original stone weather course of the aisle roof perfect, as shown on section and on the small photograph, and ranging with the angle of the nave roof. The ashlar being continued above the weather course as it would necessarily be in a dormer. The raking line of ashlar work in several of these windows, sufficiently indicating the high pitch or angle of the dormer gables, and being alike in all cases.

The diameter of the ashlar semi-circles above the windows corresponds exactly with the outer diameter of the stone beads round the circular recesses, which now show themselves on the inside of

Hall. I believe then, that we may safely take it for granted that the original treatment of this south elevation and its four windows was as shown on the drawing, and that at some subsequent period when it was resolved to give additional height and importance to the sides or aisles, the gables were got rid of, the circular lights removed, and their stone work which originally showed on the outside, walled up or inserted in the new walling. The angle shafts of the old dormers being flush with the face of the wall, were allowed to remain in their former position, and thus we have the side walls raised as they now appear with the parapet and corbel course. We have already learnt that considerable works to the roof, and to the north and south walls of Hall, were undertaken in the reign of Richard II., and Henry VI. (at the end of the 14th and beginning of the 15th centuries), and it is not improbable that these very important changes were those then described as "Considerable works to the roof and to the north and south walls of the hall." I find that the Purbeck shafts in the hall have all been thrust more or less outwards, as might have been expected to some extent in so long a roof of this construction, without any horizontal tie. It is just possible that with a view to check any further progress of this outward thrust, and to give additional abutment to the walls of the nave, the alteration in the aisle roofs may have been resorted to, undoubtedly it would have given continuous abutment to the feet of the nave rafters.

When the existing tie-beams over each column with the arched tracery work below were introduced I cannot learn, but from the detail of the tracery I imagine that at a somewhat later period than the alteration of the aisle roofs, they were undoubtedly introduced to serve as ties: and to secure the wall plate, about 15 inches square, from further thrust outwards, strong iron straps were turned over the plates and carried nearly to the centre of the tie-beam, to which they were securely bolted and the ends caulked down.

You will observe a straight joint in the ashlaring on each side of the window head, above the level of the capitals of the shafts. If this ashlaring had been returned and carried inwards corresponding with the angle of a buttress cap, one could readily suppose that the gable had some such termination as that sketched on the drawing I refer to ; but the ashlar is quite irregular and only extends back slightly, not more at the top than at the bottom. The upper part may indeed have set back somewhat before the cap commenced, as shown on the alternative drawing. Some of my friends have suggested that this long straight joint of ashlar work was merely the vertical joint at the back of knee stone (as shown on sketch), but this view is not satisfactory to my mind, or to my idea of good construction, and I shall feel much indebted to any one present for their idea as to the treatment of this particular feature. Whatever may have been the actual termination of this gable, the example of such clearly marked and important dormers in an early work of this date cannot but be interesting.

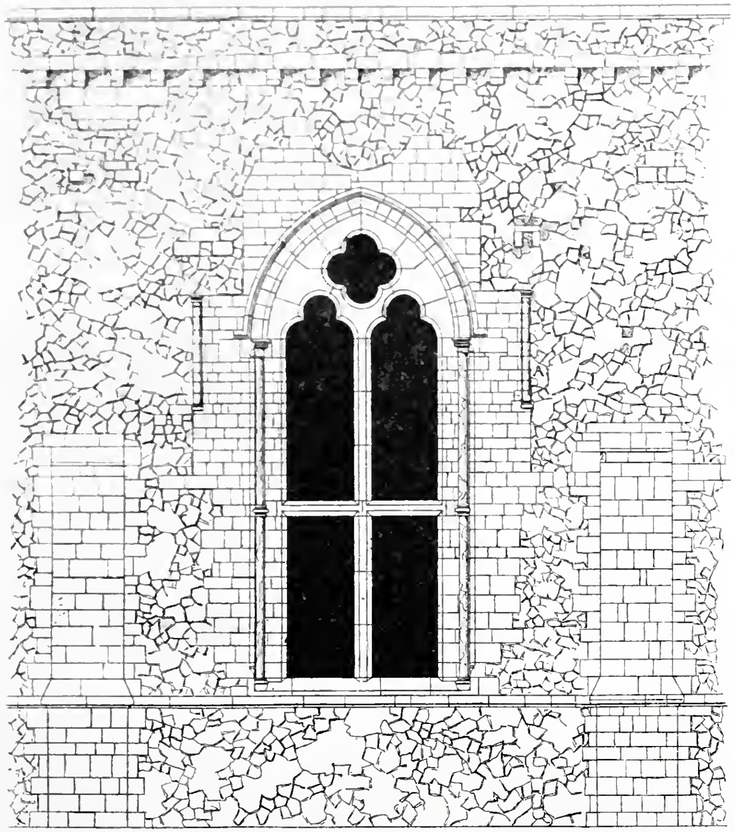
Although not so clearly developed or so general as on the south wall, there is abundant evidence in the north wall, both externally and internally, that the dormer treatment existed on this side as well as on the south.

In excavating for the south-west corner of the Nisi Prius Court, we came upon the foundations of the round tower, and by degrees these have been developed until the base is laid bare, and a vaulted chamber discovered within this tower.

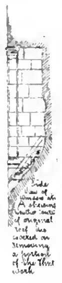
The block plan shows how this round tower connected itself with the old Castle wall of east end of Hall, and with the very interesting foundations of the keep, and of the north-east circular tower, which were discovered with the several foundations and subterranean passages shewn on the plan in 1849, when the hill on the north side of Hall was lowered, and the soil or debris of the old Castle removed.

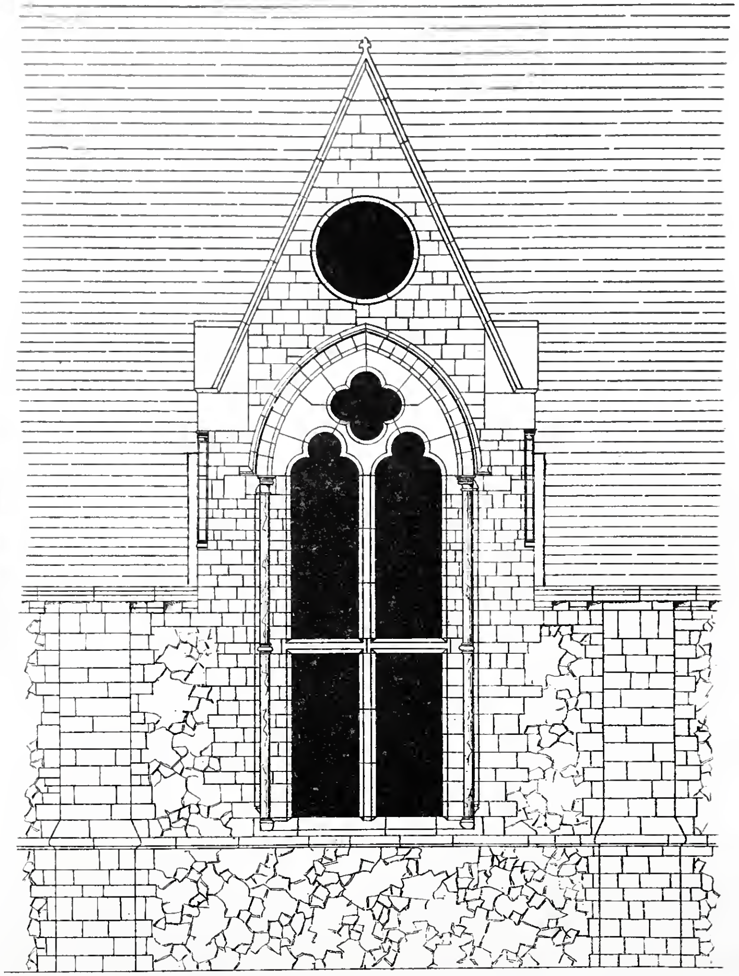
Opposite to the south original door of the old Hall, and between it and the barrack, we have found

COUNTY HALL, WINCHESTER.

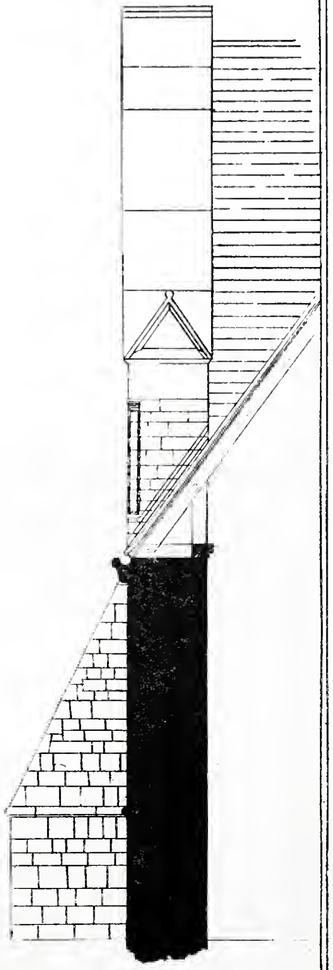


ELEVATION OF ONE BAY OF SOUTH FRONT AS NOW EXISTING.


Side view of window at A showing weather course of original roof as worked on remaining a portion of the first work



SUGGESTION FOR THE SUPPOSED RESTORATION OF DORMER WINDOWS.



SIDE VIEW.

SCALE OF 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 FEET

Photo-Lithog^{d} for the R.I.B.A. by C.F. Kell, London.

a foundation of either a pier or a portion of a doorway, as shown on the block plan, and of the form given in detail. This doorway of the old Hall evidently opened into a groined passage or chamber, of which this foundation no doubt formed part.

I now pass, gentlemen, to the modern and less interesting portion of my subject.

When I was requested by the Committee in 1871 to report upon the practicability of erecting new Assize Courts upon the only site belonging to the county, viz., the old Castle ditch on the eastern boundary of old Hall, I confess I was somewhat puzzled and alarmed when I found that the ground at the bottom of this garden was more than 30 feet below the level of the old Hall floor, and that in all probability we should find the ground very uncertain for the foundations of the new buildings. However it seemed so important a point that the old Hall should form the "atrium" or vestibule to the new Courts; and though in a secondary degree, that the existing pile of buildings to the north-west of old Hall and communicating with it should be retained for the purposes of the County offices, that I resolved to recommend that we should adapt as best we might the site now built on. Our anticipations as to questionable foundations were, I am sorry to say, more than realized. The deeper we went the worse they seemed; a mass of debris, cesspools, and pits, with remains of pots and pans, and in several places we had to provide 36 feet deep of concrete, and none of the important walls less than 27 feet, before we arrived at anything like solid ground. At last we reached a dry hard species of gravel, above the chalk. This great depth of concrete, and the necessity for having three stories in height, has involved us in a total height of 120 feet from the bottom of concrete to the top of the gables of Courts. As the superficial area for the new building was certainly limited, it was not without advantages that we had considerable height to deal with. It was necessary to provide separate cells for more than 50 prisoners, with accommodation for gaoler, turnkeys, latrines, &c. These with separate staircases leading to the docks, in both Courts, and vaults for the heating apparatus, are situated in the basement story, slightly raised above the adjoining ground, the height of the story being 11 feet.

The Committee having been fortunate enough, during the progress of the Works, to obtain a separate approach for the prisoner's van from a back street, and at the level of the basement story, instead of the more inconvenient one from the front, and at the level of the hall (which, it was believed, would have to be retained), a considerable alteration became necessary in the plan and arrangement of the hall-keeper's house or lodge, and in several of the internal staircases. But the advantages are undoubtedly more than sufficient to counterbalance the additional cost and delay which this alteration necessitated.

The *intermediate* floor has found plenty of use. It is approached by two staircases from the corridor of the principal floor, and by a separate staircase and entrance for the use of the Grand Jury and for Magistrates in Petty Sessions; as well as by another staircase from the front, for the use of witnesses in attendance on the Grand Jury. The accommodation includes a Grand Jury Room or Petty Sessions Court, a large room for witnesses in connection with Grand Jury and Petty Sessions purposes; two Lock-up Jury-rooms, and an Indictment Office, a large room fitted up for Barristers' robes, &c., a Consultation-room for Barristers and Attorneys, with all necessary Lavatories, latrines, and a Strong-room, &c. The height of this story is 15 ft.

The upper or "Court-floor" is situated five steps below the level of the old Hall, and is approached from that building by two large groined archways, formed in the thickness of the old Castle and Hall Wall, as shown on Plan, Elevation and Section. These archways open into a vestible or "Inner Hall," 34 ft. 6 in. by 25 ft., and 32 ft. high, from which there is access to the Waiting-rooms for witnesses (male and female) to the staircases leading to the public seats, and to the Courts for witnesses and jurymen.

An iron grille separates this vestibule from a corridor twenty feet wide, which gives access to the Judges' retiring-room, and to their private lobby, communicating with each Court. It serves also as the communication to the Courts for magistrates, counsel and attorneys; and by means of the two side staircases opening from this corridor, access is given to the intermediate floor already referred to.

There can, I think, be little doubt that if the smaller Courts of Justice can be made consistent with adequate accommodation for the Bar, for attorneys and for jurymen, and with a minimum of accommodation for the public and for loungers, the better will be the working of the Court and its practical usefulness. It is at best a difficult problem to arrange the position of judge, jurymen, witness and prisoner within the smallest radius that leaves sufficient room for barristers and attorneys; but that difficulty becomes proportionately increased as you add to the size of the Courts. The Committee, sharing this feeling, sanctioned the adoption of Courts of very moderate size. The Crown Court being 55 ft. by 32 ft. 6 in., and 31 ft. 6 in. high, having its grand jury box 18 ft. by 11 ft. opening into it, the Nisi Prius Court being 30 ft. wide only instead of 32 ft. This reduction in width was necessitated by the limit of the County property on one side, but it has been found abundantly large for the class of trials which are generally conducted in such Courts.

I must here be allowed to express my sense of the great courtesy and readiness with which the War Office Authorities have met all our applications in connection with the rather intricate question of boundaries between the Crown and the County properties. If they had not consented to act upon my proposition of adopting a "give and take" line on our southern boundary, our plan must have been sadly mutilated, for that boundary line would have cut off a portion of the Nisi Prius Court, and of the female witnesses' waiting room. Not only did they meet us on this point, but to facilitate the light and ventilation of the lower rooms and cells, opening towards the south, have granted a lease to the Courts of a slip of ground on the outside of the building. And further, to enable us to preserve and fence off the remains of the Round Tower, discovered on the south-east corner of old Hall (which will have undoubted interest for the antiquary), have allowed us to encroach on the barrack property at a merely nominal rent. I think it will be acknowledged that this cordiality of action between two public bodies in the interest of the public, partakes more of the nature of an exception than of the rule.

Bad as I had fancied that we should probably find the ground on which I had to build on the slope of the old Castle, I could not have conceived it possible that we should find such a state of rottenness as we did under the old Castle wall, and the east wall of Hall, which as I have said before adjoined each other. In carrying through a hot air flue from the apparatus to the large Hall, we came upon a very defective old drain, running almost in the centre of this wall; but when it became necessary to examine the foundations under the jambs or legs of the large arch which I had to make between the old and new work, and to be sure of the wall under the centre pier, so as to avoid settlements in the groined archways, we found the old walls resting in a most surprising manner on a series of pits, or cesspools, filled with black earth and slush, in a state of moisture, through which and into the adjoining ground a crowbar could be pushed some yards with little effort; the flintwork over these holding together like a mass of rock. It was not only necessary for the security of our new work, but for the preservation of the old walls and arches that this state of things should be dealt with boldly and as we hope finally. I had therefore to underpin the whole of this massive wall, in the manner shown on the accompanying plan, with Portland cement concrete, of an average width of 12 feet, and of irregular depths, according to the nature of the ground, varying from 25 feet to upwards of 46 feet.

It is not, I am sure, necessary to state to a body of Architects that this was an anxious and difficult work, requiring nerve and experience and constant care, and I cannot but express my thanks to the resident clerk of the works, and to the contractor's foreman, for the successful result. Not a crack has since shown itself in the old work, or in the rather elaborate groining in the soffit of these arches. That it was an expensive affair I regret in the interest of the rate-payers, but it was a case in which there was no choice.

There were several indications of old weakness in this part of the building; the abacus of the north-east respond had sunk 11 inches below the capital of the adjoining column; the stones in this arch were considerably disjointed, and extensive settlements had taken place in the north-east corner of the Hall. The large buttress that exists at this corner had no doubt been placed there to give support, but its own foundations were so defective that it probably added to instead of lessening the evil, and we had to underpin it to a depth of nearly 40 feet. Under this angle of the Hall an old wall was found running diagonally, the bottom being at a depth of about 20 feet, and the upper portion of wall within about two feet of the Hall floor. This was doutless part of the earlier foundations shewn on block plan.

Flint mixed with stone being the materials with which the old Courts were faced, I felt that the new work which was ultimately intended to group with and form part of the older work, must be carried up with a similar treatment, and as flint is so thoroughly the material of that district, I decided on building the main walls with that material, bonding them with courses of brickwork in cement and iron hooping at certain levels, the inner and thinner walls being of brick.

The concrete has been formed of local grey lime (which is an excellent material, like the Dorking lime), mixed with gravel and broken bricks, in the proportion of about three parts of each to one of lime.

It was to be expected that in walls of such great height and considerable substance (the work being pushed on somewhat more hurriedly than I liked) there would be, in flint-work, some slight pinches or inequalities of bearing. They were however but slight, and as the mortar hardened and the whole mass consolidated, these ceased, and the walls appear perfectly solid.

I have already trespased too far on your attention, and shall add but little here.

In the way of decoration, the Committee hope to fill all the windows in the old Hall with heraldic glass, giving the Arms of all the celebrities in the History of Hampshire, painting on the walls of the vestibule the armorial bearings of all the Lord-Lieutenants of Hampshire, and in panels over the dado of the Magistrates' room (after the manner of college halls), the Arms of the various Chairmen of Quarter Sessions, thus giving a sort of County historical interest to the old and new work. Those architects present who have had the charge of large public works will, I am confident, agree with me in thinking that a small Building Committee is not only a boon to the architect, but in all probability of great benefit to the work in question. I was fortunate enough to have appointed, to aid me in this work, a Building Committee of only three Magistrates, Mr. Melville Portal and Mr. Esdaile (the two Chairmen of the Courts in Quarter Sessions), whose experience in the working of Law Courts has been very extensive, and Mr. Yonge, a Magistrate, residing in the neighbourhood, who inherits, and possesses himself, a great love for antiquarian subjects. I cannot close this paper without bearing testimony to the incessant zeal and interest which they have taken in this work, and to the personal kindness and confidence which they have shown to me. There have been some slight differences between us on matters of taste; but where those existed (and they have been very trifling), I felt that, as the guardians of the work, they had every right to decide; and I have contented myself with the expression of my opinion and of my reasons.

Messrs. Hill & Son, of Islington, have been the Builders engaged, and in the main I have much reason to be pleased with the zeal and energy shown by Mr. T. Rowland Hill, the partner who has had charge of the work. Architects know well how often it happens that up to a certain point in a large work of this kind, everything goes smoothly, and the progress appears all that could be desired; but that, in the later stages of the work, their patience is often tried, and (the wish being father to the thought), they fancy the work could be pushed on much more rapidly. I will not say that such may not have been my own feeling in this case, but I do know that here, as in other matters, "there is a great deal to be said on both sides."

We had a most valuable and experienced assistant in Mr. Tookey, the Clerk of the Works, and the Builders had a very trustworthy and anxious foreman in Mr. Houghton. The carving has been done by Mr. Broad, and the heating and ventilating by Messrs. Haden, of Trowbridge. The Purbeck marble shafts of the Hall are now undergoing restoration by Messrs. White, of Millbank.

The expenditure on these works will probably amount to £22,000 on the new Buildings; £3,500 on the restoration of the Hall, including a new oak roof throughout, and the restoration of the Purbeck marble; £2,510 on the County Offices.

The cost of the new Buildings gives a price of about 11*d.* per Cubic Foot.

The PRESIDENT.—I hope some gentlemen will offer some remarks on this interesting subject for our further information, although perhaps it would be rather difficult to do so after so exhaustive a Paper. We have present an eminent archæologist, Mr. Burtt, who, I believe, has been kind enough to look over the Public Records which bear upon this subject; whether beyond those given by Sir Edward Smirke, I do not know.

Mr. J. BURTT, Visitor.—Acting upon your suggestion, Sir Gilbert, I have attempted to add somewhat to the information so well conveyed by Sir Edward Smirke, in his paper in the Winchester volume of the Archæological Institute. The great point of interest in that paper as regards the discussion this evening, is with reference to alterations in the form of the Hall made in the latter part of the fourteenth century, according to documents quoted by Sir E. Smirke, and demonstrated to be of considerable importance by the excellent lecture we have just heard. I was aware that, at the time that article in the Winchester volume was written, the documents which gave detailed information of such works were in an incomplete and imperfect state, and I thought it might have been my good fortune to get into a fresh field of new matter, and that I might have an opportunity of laying before you some information much in advance of that given by Sir E. Smirke; but I find Sir Edward speaks of the attention which he received from Mr. Hunter, who was in charge of the Records referred to, and who took extraordinary trouble to lay these documents in detail before Sir Edward. The consequence is, that when I went carefully through the first roll of 6th Henry III. to see what information I could get on my own account, without looking at what Sir Edward had done, and after comparing it with what he had done, I found he was in possession of all the information afforded by that roll. There was, however, a little more upon one of the membranes which is not very material. One curious entry is omitted. There is the payment—"Audam nuncio qui ivit pro Girardo le mineur 4*d.*" This *Girard le mineur*, it would appear, was called in to deal with some of the old foundations of the early structure, because we find there is this direct payment made to him, viz., "Gerardo le mineur ad purgendum fundamentum nove herris et ad prosternandum unam partem muris—60*s*." That must show a dealing with some of the very early portions of the structure, for the purposes of some of the alterations made in the thirteenth century.

Coming to the period showing the date of the great alterations in the form of the Hall, I took up the roll of "Foreign Accounts," quoted by Sir Edward Smirke, in which are the entries for the repair of the aisles of the Hall. The rolls of "Foreign Accounts" contain entries of matters *foreign* to the ordinary business of the sheriffs. The entries of the sheriffs are made upon the Pipe rolls, which are very large and cumbrous documents. And the rolls of "Foreign Accounts" are nearly as large as the Pipe rolls. This roll of 16th to 22nd of Richard II. consists of fifty membranes, each of two skins of about six feet long and fourteen inches wide, and written closely on both sides. The labour of searching through such rolls is very considerable, and would be more if it were not for the aid given by a note of what is entered upon the roll. But on this roll of sixteenth Richard II. these notes are exceedingly imperfect, and necessitated a careful examination of the whole roll. I am sorry to say I have missed the identical entry which Sir Edward Smirke gave, referring to the aisles of the Hall; and for this reason Sir Edward does not give the exact year to which the entry refers. The roll extends from 16th to 22nd Richard II., and each of these years is subdivided into a series of rolls numbered by the letters of the alphabet. The whole of the accounts for the sixteenth year run to letters H or T, and if Sir Edward Smirke had noticed that, he could have given direct reference to the exact roll he quoted. Consequently, in looking through the roll, which is not in very good condition, I did not catch the entry; but I found several others confirmatory of the passage given by Sir Edward, only they do not, I think, bear out the construction which Sir Edward has put upon that given by him.

Sir Edward speaks of the repairs done to the two aisles of the great Hall as being, by "an order under the Privy Seal, issued in the thirteenth year of that reign." That looks as if the repairs were executed under the order of that date. This, however, is not the fact. The order of Privy Seal of 8th April, anno 13, directed the bailiffs of the city to expend 40 marks out of a fee-farm of 100 marks annually, upon the repairs of the walls and castle of the city; but does not state what those works were to be, thus differing entirely from the earlier orders directing *specific* works, and referring only to what must evidently have been of the simplest character. Going farther back, with a conviction that there must be something more, I examined the preceding roll of Foreign Accounts, extending from the eighth to the fifteenth year of Richard II.—a similar roll about the same size as the other, and containing about the same amount of material; and in that roll I found another entry relating to repairs of the great Hall, with a similar passage—"*de novo facte.*" The passage Sir Edward quoted refers to the Hall as "*quasi de novo facte.*" This passage, taken with the other entries, seems to me to refer decidedly to very considerable alterations made some years before, and the entries upon the roll 16 to 22 Ric. II., refer only to simple ordinary repairs which the Hall, much altered a considerable period before, had undergone, as a matter of course. I think, therefore, that the construction put upon these entries by Sir Edward has hardly been borne out; but it must be recollected that it was not Sir Edward's point to trace the architectural history of the Hall, but rather to grapple with the difficulty which existed as to whether this was originally a hall, or an ecclesiastical structure, and his object was to show that it was the great hall of the castle. Into the question whether alterations were made in the 13th or 14th century, Sir Edward did not enter. I am inclined to think the facts may be ascertained by those who have the time and patience to do it. That the records do exist, I feel pretty certain. Sir Edward says he did not examine all the pipe rolls of the period. And if any one would work upwards from the period I have myself examined (the sixth year of Richard II.), he would probably light upon something which would give more information on the subject. There is another class of documents on which I had hoped for some information, that is, the accounts of the clerks of the works of the king's castles; but Winchester was entirely the king's city, and from the earliest times the works in Winchester were paid for by the sheriffs, and they appear in a very voluminous form on the early Pipe rolls. In conclusion, I can only express my regret that, with the limited time at my disposal, I have been able to offer you so very little additional information on this subject.

Mr. T. H. WYATT.—Mr. Street is interested in this subject, because he worked with Mr. Carter, and the centre doorway was drawn by Mr. Street. He suggests the possibility of there having been merely a wooden terminal, and that the rafters ran through, and he has doubts with regard to the question of the stone coping. But I think that where there was so much ashlar work the gables in all probability were formed entirely of stone. It is a curious thing that the old hall of the Palace at Hereford corresponds with this Hall in length and width, and is similarly treated in its details. That is Norman work, and of earlier date than this, and there is one at Oakham, which is smaller, but of very much the same proportions. It is the gabled dormer which is the feature of great interest.

Mr. HORACE JONES, Fellow.—If there were gable walls at the east and west ends, that would indicate the mode of treatment of the smaller gables. I think it likely the tiling projecting over the wall protected the wall.

The PRESIDENT.—It was not covered with tiles at first, but with shingle.

Mr. T. H. WYATT, in reply to inquiries, gave explanations from the drawings, in reference to various points of construction.

Mr. HORACE JONES.—With your permission, Mr. President, I think we may now proceed to pass a vote of thanks for a paper, which, if shorter than many which are brought before us, contains a very great deal of valuable and interesting matter, presented in the most pleasing and agreeable way, and which at its conclusion has afforded us an opportunity for a little practical discussion. I am sure our President, and every one in the room, will cordially unite in expressing our best thanks to our late President for the excellent and pleasant account he has given us of this very interesting building.

Mr. I'ANSON, Fellow.—I have great pleasure in seconding the motion.

The PRESIDENT.—I am quite sure you will pass this vote of thanks unanimously. Mr. Wyatt, I have great pleasure in conveying to you the thanks of the Meeting, and in doing so I beg to express my great interest in the paper you have read, particularly the part relating to structural details, the more so because I had the privilege of going over the work and examining it under your kind auspices, and since then I have taken the liberty of looking over it with your clerk of works. I have known the Hall in its former state, but your discovery of the long slope of the roofs, and the curious dormers with the gable wall over, is most interesting, because it is very rarely that we see an example of this kind on so magnificent a scale, and as you say, the evidences of this are very distinct on both sides of the wall; but it is not so easy to understand that curious vertical quoin which comes on to the haunches of the arches. Anticipating your concurrence, I took the liberty of asking Mr. Burtt, who has ready access to the ancient documents, which he has mentioned this evening, if he could find any information in addition to what Sir Edward Smirke has given, and I think he has thrown some additional light on the subject this evening. He has shown very clearly that entries which we imagined referred to Henry Second's time, did not refer to it. I felt a doubt about it myself. It speaks of repairs. This large work can hardly be called repairs, and the items spoken of would seem to refer to repairs subsequent to the larger work having been completed. In one case it speaks of labour of plumbers fitting windows in new places, and my impression is that it refers to alterations effected soon after the larger work was done. The whole hall is extremely interesting, and it will look very magnificent when it is thrown open. [Mr. WYATT.—I do not know whether you think the tracery of the arch beams might have been of the reign of Henry VI?] The PRESIDENT.—Very likely, indeed; the reign of Richard II. would be the time of Wykham's works, and I do not think he would have done anything on so small a scale.

Mr. BURTT.—In the 13th of Richard II, the accounts speak of an expenditure of £26. 13s. 4d., and I need not say no great work could have been done for that sum, but the entries all speak of repairs, and that being the amount apportioned by the Privy Seal in the 13th of Richard II, the bailiffs took care to expend exactly that amount, neither more nor less.

The PRESIDENT.—I may add I think we owe a debt of gratitude to Mr. Burtt, and I would strengthen that by saying that that gentleman has been obliged to leave his general occupation for a considerable time in order to arrange the papers of the late Mr. Albert Way. My letter reached him just after he had completed that task, and he immediately set about the investigations of these enormous pipe rolls, the labour of which we can readily imagine.

The Discussion on Mr. Wyatt's paper having thus been brought to a close, the Meeting adjourned, after passing an unanimous vote of thanks to the author.

Royal Institute of British Architects.

At the Ordinary General Meeting of the Institute, held on Monday, the 18th May, 1874, H. Currey, Vice-President, in the Chair, the following paper was read:—

ON TOWN AND COUNTRY SCHOOLS.

By T. Roger Smith, Fellow.

Gentlemen,

Education for the masses of the English people has only been provided during the course of the nineteenth century. The work begun by enlightened benevolence, has been continued by legislative help. Latterly, especially within the last five years, school-houses have multiplied so fast that it is difficult to find any architectural movement of modern times so fairly meriting to be termed universal. Apologies are therefore not required for the subject itself; but for the manner in which it has to come before you I have to ask your indulgence. We had all hoped to hear the results of Mr. Robson's wide experience from his own lips, and I feel that it cannot but be a great disappointment to you to be deprived of this pleasure. Nor have I even been able to do full justice to my own idea of what a paper to be read before this Institute, on this subject, ought to be; for the short time which has elapsed since I undertook the task at the request of the Council, has been unavoidably broken in upon by other engagements, which have left me far too little leisure for preparation. It is some consolation to reflect that nothing short of a volume can do justice to the subject, and that such a volume, from the pen of Mr. Robson, has just been issued from the press.

The grammar school and the charity school were the appliances in operation at the beginning of this century. Grammar schools were chiefly filled by the sons of persons above the class of labourers or operatives, and charity schools were almost the sole provision for the education of the masses of the people. Two years before the century opened, namely, in 1798, Joseph Lancaster established his first school. His name was connected with the system of education adopted in the early schools erected by voluntary societies. A Lancasterian school was a square room, often of large size; for Lancaster said he should not be afraid to place as many as a thousand children under one master, in one room, though I am not aware whether a single school for so large a number was ever built under his system. The work was partly directed by selected pupils called monitors; but the instruction was, I believe, chiefly given by the master, who taught the whole school simultaneously. Here then, we have a system in which the children of one school were taught *en masse*, and were crowded together into one group, and a building appropriate to such a purpose. The steps which education has made in England up to the present day, may be said to have started from this original plan, and their general course has been constantly towards the principle of separating children more and more into distinct classes.

It was, I believe, in 1834, that grants of public money, in aid of buildings, were first made. In 1839 the Committee of Council on Education began to administer these grants. In 1840, plans of buildings were first issued by the Committee, and as by this time a change had come over the mode of teaching, the buildings had assumed a corresponding difference of aspect.

The system of pupil-teachers had now come into use. This as you know is a plan by which promising scholars are apprenticed to learn the business of teaching, receive a small payment, and are available to act as auxiliary teachers. By this system, a series of young teachers was brought forward, of whom many were fairly competent to instruct a class, but required constant supervision, and the support of the master's presence. The simultaneous teaching, though not abandoned, ceased to be a first consideration, and a school had to be devised in which a series of classes could be taught; each class to a large extent shut off from its neighbours, yet all in the presence and within the reach of the master or mistress. Here we have the rationale of a form of building which, I have no doubt, is familiar to every architect present. The children in each class were to sit three deep, and no more, so that even a young teacher might have no difficulty in reaching them with the voice and seeing them. The classes were ranged side by side against the wall of a long school-room, and could be all addressed as one; but at the teaching hour each class was cut off from the classes right and left of it by a curtain. Enough floor space was provided in front of the children's seats, to enable the teacher to bring them from their places and group them standing round him. For these purposes, a long room from 16 to 20 feet in width, that is to say averaging 18 feet, was prescribed, and it often took the shape of an L or T in plan, so that the head master or mistress could, from the point of intersection of the different arms, readily see all the classes. Windows were ordinarily introduced on both sides of the room, to admit a through current of air. Great pains were taken to preserve one side unbroken by doors or fire-places, so that a range of classes might occupy the wall without interruption, and no children were so placed as to face each other. Beyond this degree of isolation, however, another step was made in the establishment of one or more class rooms, but commonly only one for each department, in which one of the classes could be instructed away from the noise of the general school-room. School buildings of this sort, sometimes mixed, *i.e.* for boys and girls taught together; sometimes consisting of a pair of buildings, one for each sex, and with or without an infant's school as part of the group, have been built by hundreds and thousands.

As a preparation for these schools, the establishment of infant schools was, at a very early day found necessary. Sometimes they form distinct schools, sometimes they form a department, and here let me explain that throughout this paper the word *school* must be understood to mean a whole building, and *department* that portion appropriated to boys, to girls, or to infants, as the case may be. There can be little doubt that the simultaneous mode of teaching, which has been to a large extent given up for the elder children, is the best for infants. In short, the training in an infant's school is much like drill. The little ones march, move their hands, clap, stamp, and manœuvre simultaneously, and in a body; consequently plenty of space for them to move about in, as well as a spot where a number of them can be seated in one mass to be taught, are required. For collecting the infants together to receive a lesson, a sloping platform, considerably raised at the back, and known by the inappropriate name of a gallery, is employed.

In the infants' school there is always a class of children to be found whom it is desirable to withdraw from the general mass, not on account of their being employed on work which needs undisturbed attention, but because they are too infantile to join even in the childish occupation of the others. A class of babies is consequently generally to be found in a separate class room. As, on the other hand, the course of instruction in an infant school is very noisy, it is well to have another class room in which some of the more advanced children can be instructed apart.

Thus we arrive at a roomy school-room, and two class rooms, as the basis for an infant's school.

The marching and drill are most conveniently carried on in a room wider than an adult school-room, and a width of 25 to 26 feet seems recognized as sufficient. An infants' school should always be on a ground floor, to avoid trouble and difficulty in taking the little ones up steps, and when schools for advanced children are to be built on upper floors, the problem how best to obtain extra space below them presents a difficulty best met by throwing out a large recess from the principal school-room, and placing the gallery in it. The gallery is best lighted from the top, an arrangement favoured by placing it in a recess; light from the side is the next best, but the gallery is not well lighted, if light only comes from the back or the front, and for the following reason. If the light comes from the back of the gallery, it shines indeed on the teacher's face, sometimes too strongly, so as to dazzle her, but the children are not lighted up, and the teacher, who depends largely for success on being able to read the expression of their countenances, cannot tell what impression she is making on them. If, on the other hand, light is from the front of the children, their faces are illuminated, it is true, but they are not able to see their teacher, and she loses a great deal of her influence over them in consequence. The gallery should not contain more than about 70 children, arranged five deep or six deep; the gangways should be at the sides, the seats with backs. Sometimes two such galleries are placed side by side, with a sliding partition between them, so that an occasional combined lesson can be given to 140 children. A few desks and benches (the desks with flat tops) should also be provided in the school-room. The class-room for elder infant children, where there is one, also requires such desks and seats. The babies' class room has a gallery. It is not considered that an ordinary infant schoolmistress can manage more than 250 children in a school, and it is consequently undesirable to build an infant school for more than that number.

This outline may fairly represent the infant schools of the present as well as those of past years; but when we return to schools for boys or girls above the age of infants (now often called "graded" schools, because the children are separable into six "grades" or degrees of proficiency), we find if we enquire into what has been done since the passing of the Education Act, that considerable variations have been introduced. In Leeds, I am informed, that school rooms of great width, approaching an old Lancasterian school, have been erected, thus of course preparing for more or less of a return to the simultaneous system of teaching, or at least relying upon the master's power of influencing large numbers. Details of arrangement in these schools are not, however, in my possession, and it will be better to proceed at once to some of the work of the London School Board, and the variations introduced in their schools. Their general principle has been to isolate a larger number of classes than before, but not to render it impossible to bring together all the classes of one graded school into a general room. The usual arrangement of one department of one of their graded schools may be said to be that a school room and two class rooms are furnished; often one class has a class room to itself, two others being taught in a large class room divisible by a sliding partition into two halves, so that when separate teaching is going on there may be a tolerable separation of one class from the other. In many instances, however, both the class rooms are so subdivided. The remaining pupils, forming one half of the number in the department, are then taught in the school room, and when a lesson is to be given to the whole department, the children are brought in from the class rooms and crowded together into the school room.

We are thus landed exactly half-way on the road towards the system of a separate class room for each class; and for the time being it is thought we have gone far enough; perhaps the experience of a few years may shew that another step in the same direction is not so impossible as it is now believed to be.

The increased separation of the classes is not, however, the only modification introduced into the old scheme. If you visited any good school not under Government inspection—and indeed in many that are so inspected, the same arrangements existed—you found desks and seats placed four deep, and even five deep, instead of three deep, and ten to one the teachers tell you they would sooner have the children massed in front of them, so as to be well under the eye, than spread out to right and left, till they cannot be all taken in by the eye at one moment. It was early decided to provide for teaching in the London Elementary Schools a greater number of rows of children than three, and school rooms were accordingly built 22 feet wide, or from that to 20 feet, the class rooms being 20 to 18 feet wide.

Confusion, crowding, and inconvenience, were to be detected in a school with benches as much as 12 feet in length, and sometimes occupied by as many as eight children in a row, if you watched the working of a class even only three deep, when (as in a writing or ciphering lesson) the teacher required to go near to each individual child, especially if the child was in the middle of the middle bench. Much more serious did this become when the class was arranged four deep or five deep. This difficulty is of course not felt in Swedish and other schools where each child has a separate seat and separate desk. But a great loss of room is thereby occasioned and the fittings become expensive. Eventually, therefore, it was decided to seat the schools with short benches and desks, each long enough to hold two scholars. By leaving a narrow gang-way between each line of desks the master can go to any boy or call any boy out without disturbing the class. The whole class can also leave or enter their desks at one time with great ease. A very judicious economy of space, combined with great improvement in comfort, has also been effected by curtailing the width from front to back allotted to a desk and bench by the old rules of the Committee of Council, causing the edge of the desk to be vertically over the front edge of the bench when pupils are seated, and desks each with a flap to turn up when they are to stand. Every portion of this contrivance will be found to have received careful attention, the result being, I think, a fitting not likely to be much improved. In these desks, then, the distance from back to front is from 23½ to 26½ inches, the mean being 25, so that five rows of children will average 10 ft. 5 in. The desk and bench for two pupils are 40 inches long, and the intervening gang ways are 16 inches wide. The floor space to be allotted to each child is not less than nine feet in the graded schools and eight feet in infant schools ; 13 feet clear for graded schools and something more for infant schools may be taken as a proper height.

The desks and benches being designed, and the space they will occupy settled, the next question which presents itself is, how are they to be lighted? This is a question of more importance, and I may add more complication than has been often believed. The Germans, whose thoroughness is proverbial, design each room with exclusive reference to the light that is to fall on the desks, and modify the design of the whole building if necessary to a large extent, so as to secure the aspect they require for the windows. In a German school the light *always* falls from the side of the pupils, and *always* from their left hand as they sit to write; and it falls from nowhere else. No cross lights are allowed, and if there is a difficulty in reconciling a convenient arrangement of seats with lighting from the left, then the convenient arrangement of seats must give way in order not to infringe this cardinal rule. The reason why lighting from the left is good will be obvious when you reflect that in writing and ciphering this is the only side light which prevents the shadow of the hand from interfering with the work. The advantage of side light over light from behind the children is that the teacher is not dazzled, and the children's faces are not lost to the teacher, and the children do not sit in their own light. The advantage side light possesses over light from behind the teacher is that the children are not dazzled, and as I already have observed with regard to infant schools, that their teacher and his diagrams and maps are easily seen by it.

The rule of lighting from the left cannot practically be carried out except when the teaching is in class rooms, for if in a school room where several classes are taught you attempted to place the children with their seats at right angles to the wall, you would be landed in a series of inconveniencies so grave that they could not be tolerated. Nor can the rule of lighting only from one side be easily made consistent with that passion for through ventilation by means of a direct current of wind from window to window, which has so strong a hold upon those experienced in school management as well as hospital management in England. Accordingly the practice with regard to school rooms has been at the best a compromise. As much side-light as is obtainable has been in some of the recent London schools procured from the ends of the general school room, but for the majority of the classes there taught windows both back and front are commonly supplied.

The position of windows should be high, their tops as near the level of the ceiling as possible, and their cills at least four feet from the floor. If higher so much the better. The dimensions of the windows if centrally placed in the room, should suffice to furnish one superficial foot of opening to every eighty cubic feet within the room. A less proportion of glass suffices for a skylight.

The aspect of school and class rooms has been much discussed. If on a town site there is an aspect where quiet can be better secured than elsewhere, or where a greater volume of light is obtainable, that aspect it will generally speaking be wise to occupy with windows; but if there be free choice it is right to secure the best light, namely the northern and eastern light for work, and the sunny or southerly aspect for warmth and cheerfulness. It is not healthy for the sun never to reach a room, it is not comfortable for the glare of such summer sunshine as we occasionally enjoy, to stream in at all the windows of a school or class room. The principal light for the pupils is therefore best obtained from the north and east, with other windows to the south and west. The glazing should always be with clear glass. The panes not extremely large. The greater portion, if not the whole of every window, should open, and if any part be fixed it should be the lower part. The worst mode of opening school windows is the ordinary sash, as it lets in a direct draught, and the common casement is open to pretty much the same objection. The best mode, by far, is the casement hinged at the bottom, and made to fall inward at the top, often called the hospital window. This will give a large amount of air with the minimum of draught, as the air entering the room is directed upwards. The casements of one window can be connected together by an iron rod, and all shut and opened simultaneously with ease. Cords and pullies are not desirable for use in schools. In very bad neighbourhoods a protection of wire netting is sometimes added outside the window, to prevent injury from stone throwing. It should not be adopted when it can be avoided. In contriving windows a place where a blind can hang should not be forgotten. In planning them the light should be pretty evenly distributed over the school or class room; and both on this account and to give more perfect control over ventilation, several windows of moderate size, are generally preferable to one large one.

The actual size of the majority of the schools—embracing all three departments, recently built by the London School Board has been usually either for 1040 children or 780. In the former case the numbers are 400 infants, 320 boys, and 320 girls; in the latter 300 infants, 240 boys, and 240 girls. The buildings have commonly been three stories in height, the infants having the ground floor, and the boys and girls each one of the upper stories. Very frequently a part of the ground floor has been devoted to those most desirable adjuncts, covered play grounds. Indeed, in many cases, the infant school is a separate building, and the graded schools are of two stories in height, one for boys, and one for girls, with covered play grounds under the whole space they occupy. These play grounds cannot be too sunny. They should not be draughty if it can be prevented. There is some difficulty in apportioning the numbers in theory, into the classes corresponding to the six grades of the Education Department, owing to the fact that the number of children in the higher grades is always smaller than the lower ones, but in this as in others things theory always differs from practice, and with 240 children six classes of 40 would be prepared for, half the number to be taught in class rooms, half in school rooms. Originally the class rooms were required to open out of the school rooms, the doors having glass in them, and when there were double class rooms with a sliding partition to connect them together, it was desired that both halves of the double class room should open out of the school room. It is to be observed, however, that in recent schools, such as some of these figured in Mr. Robson's book, the class rooms have an independent communication with the staircase, and indeed in the school which he selects as a model, they do not open out of the school room at all, a significant advance in the direction of more complete isolation.

The best position for the class rooms is across the two ends of the school room, leaving the wall facing the children in the school room free for cross ventilation, and if it be not considered essential for them to open out of the school room direct, there will usually be no difficulty in so placing them as to permit side lighting for a portion of the classes in the school room itself. Even, however, where this has been possible, it has been taken as a fundamental principle to start by placing the school room so that the windows at the backs of the classes shall admit north light.

There ought to be no corridors. As in older plans, the whole of the openings and breaks for doors and fire places in the school room should be in one wall, so to have the opposite wall free from end to end for seats, but the old L shape and T shape is not to be found in the school rooms of these recent schools, but a shorter and wider room, of plain rectangular plan, takes its place.

It is desirable where the schools are large, that there should be two staircases to each department. The place for the staircase is in the angle between class room and school room, and in a school of the most perfect arrangement, such for example as the one at Angler's Gardens, figured as "a model arrangement for a school of the kind," in Mr. Robson's book, the points attained are tabulated by him as follows :—

1. No space wasted in corridors.
2. Double exits, so that one part can be cleared without disturbance to the remainder.
3. The same number of class rooms as classes in the school room.
4. Side lighting in every case.
5. Class rooms arranged in pairs for working by a certificated master and pupil teacher in each case.

Class rooms arranged in pairs imply some means of throwing them together and separating them at pleasure. Moveable partitions of various sorts have been tried for this purpose, sometimes sliding up like sash windows, sometimes running forward on rollers upon grooves in the floor, sometimes hung at the top. Mr. Stones has patented a sliding partition, which seems as fairly successful as any; but my own impression is that none of them answer well or ever will answer. Where they must be employed the best arrangement is to have two parallel to one another, with a space between. Even this will not keep out sound. I believe it will be impossible altogether to prevent injuries to children arising from their use, and I cordially echo the observations in Mr. Robson's book that "There is no known moveable partition which is at once simple, easily moved by a child, and perfectly sound proof. Whether for this reason or because of the additional expense, moveable partitions should never be adopted, unless the working of the school should render them absolutely necessary;" and further on "The fewer specimens in use in any school, the better will probably be the condition of the school."

In the Orange Street and Mansfield Place Schools for example, pairs of class rooms will it is true be found, but the separation between them is by a wall, with a door of communication, to enable the teacher to pass from one to the other as occasion requires, and this arrangement seems on the whole an advance upon the sliding partition arrangement. It is fair, however, to observe, that in the famous

American schools, sliding partitions are constantly made use of, and that to such an extent, as to permit several adjacent rooms to be thrown together.

We now come to the staircases. They require to be so placed that boys and girls can go separately to their different departments of the schools, and can enter at distinct entrances; but in many places these objects can be well accomplished without two distinct staircases, by the use of one of those arrangements where stairs starting from two distinct points follow each other between the same four walls. Staircases to be used by children should have no winders (though I do not think all the Board Schools have adhered to this rule); they should not have more than 6 inch rise. It is not found necessary to make them wider than from 3 ft. 6 in. to 4 ft., though sometimes wider stairs with a handrail fixed up the centre of each flight, as well as up the sides, are found to answer well. The flights should be short—the landings wide, and if possible there should be no open well hole. The best sort of staircase for a school is the one where a wall takes the place of a well hole, and with the aid of this central wall two staircases can be obtained perfectly separate from each other in two different ways, the flights can either cross one another or follow one another.

A staircase once almost universally used in schools is one where three short flights run round three of the sides of a square tower, with a landing on the fourth. It is now very much abandoned and I think wisely, for it has led to fatal accidents owing to its open well-hole; and at the Cowper Street Middle Class Schools where such staircases are in use, they are caged in with iron-like prison bars—an arrangement which even in lunatic asylums is now disused if possible.

The reason just given for avoiding an open well-hole is one which ought never to be absent from a school architect's mind. Children *will* injure themselves if they possibly can, and will from pure heedlessness or from mischief injure anything else they can get at. Everything therefore which might do them harm, or to which they might do harm, must if possible be dispensed with.

The other adjuncts within the building ought to be a lavatory, and a cloak-room for each department. These need not be high, and as the height of school rooms is considerable, a mezzanine cloak-room may often be introduced with advantage. It is desirable for the cloak-room to have two doors, and a sufficient number of strong wrought-iron pegs. The lavatory should have, it is considered 2 to 3 basins to each hundred children, each basin to have a separate cock.

Outside the building the childrens' conveniences should be placed—these ought to be arranged in a straight line, and are best furnished with a trough of slate or iron, or a pipe of drain tile in which water stands constantly, and from which it can be drawn off with a rush two or three times a day. The number of latrines should be, according to Mr. Robson, three for the first hundred, and one in addition for every succeeding fifty: this is certainly the minimum number. Of course they are to be perfectly distinct for boys, girls, and infants; and separate accommodation is to be provided for teachers and for care-taker.

We have named covered playgrounds as procurable in many cases below the school-buildings. Where this is not done, a play-shed open towards the south should be provided for each department; or at least two, one for boys, and the other for girls and infants to use in common. Drawings of playground fittings are so seldom required that I hardly need detain you about them, but it is often the architect's duty to advise as to how to cover a playground. The question is not easy. The London School Board have decided it in favour of tar pavement, which is cheap, and answers fairly well, if well done; but it is not so durable as the better sorts of asphalte.

A teacher's room is a necessary appendage to each department, and a set of rooms for the care-takers who reside on the premises is usually provided in a convenient part of the school block.

It remains to consider for a moment the heating and ventilation of these schools. The lighting has been already disposed of, as it is a primary consideration in determining the disposition of the building.

For schools of moderate size, that is to say up to 500 children in all, the London School Board have preferred open fires. For their larger buildings they have adopted systems of heating from a central apparatus. The original cost of an apparatus is of course considerably greater than that of open fire places, even including stove-grates and the brickwork of chimnies and chimney breasts, but it is a far more scientific mode of heating, and more economical of fuel; and as experience is gained in the construction of such apparatus, it is not impossible that they may be extended to smaller schools.

Of the stove-grates capable of being employed in schools where open fires are used, Mr. Robson enumerates those known as the Galton, Manchester, Boyd, Pearce, and Longdon grates. Of these I am more familiar with the one invented by that very ingenious engineer, Mr. Boyd, than with the others, and it appears most admirably contrived to obtain the largest amount of heat possible from the fuel consumed, and to throw a large quantity of warmed fresh air into the room.

In two schools which I have erected for the London School Board, a warm air apparatus has been adopted upon my advice. In the larger of the two, that at Stepney, a most careful investigation was made of the proposals submitted by six engineers, and it resulted in the adoption of those of Messrs. Price & Co. Fresh air is admitted to a chamber on the basement, where it is warmed by passing between flat vessels in which hot water is circulating at low pressure. The air so heated is conducted along flues carefully built for the purpose to every room in the building, and discharged through inlets near the floor. A class room 20 feet by 27, and 13 feet high, has for example two of these inlets, and practically a current of sweet and warm air is constantly pouring into the room through each of them. Near the ceiling of each room is an opening leading to an extracting flue. All the extracting flues are led into air trunks running along the roofs, and meeting in a central chamber, where a nest of vessels similar to those employed to warm the air is fixed. This acts as a rarifier to stimulate the outgoing current, and a steady stream of air is found in actual practice to be constantly flowing out of each room along these extracting channels.

The other school was warmed by Mr. Boyd on the same general principle, but with various differences in detail, the principal ones being that he heated the air by coils of pipe instead of flat vessels, that his inlet flues were very different in dimensions to those designed by Mr. Lea (who represents Price & Co.), and that no extracting apparatus was attempted beyond the provision of outlet flues with suitably protected exits. In this building, as well as in the other, a consistent stream of pure warm air issues from every opening when the apparatus is going, and therefore there can be little doubt that the outlets work efficiently without the stimulus which in this instance the disposition of the building forbade my attempting. Here we have systematic warming, combined with ventilation for the weather when the windows will not be opened, and I have little, if any doubt, that this is the best possible system to adopt in schools of large size; though of course the arrangement of different buildings may occasion modifications of the details. For summer weather ventilation by means of open windows and windows on more sides of each room than one, is of course indispensable.

It has been sometimes customary to warm schools by taking the pipes into the rooms. This I need hardly say is a very imperfect mode of ventilating, though it is a powerful mode of heating, and may fairly be employed as an auxiliary to the warm-air system I have described. The first cost is decidedly less, but the results would be less healthy. If, however, economy drives the architect to such an apparatus, he should beware of any high-pressure system. The high temperature to which hot water pipes can be raised on the high-pressure system renders their effect on the air of a school injurious to health and comfort. The sort of heat which is suitable for dessicating timber is not favourable to young children or their teachers.

Elementary schools such as the ones I have described are considered by those who have the best opportunities of judging the most appropriate to the wants of a large and crowded metropolis like London, and to the requirements of our present system of teaching; and they ought to prove good models for town schools throughout England. For country schools they will in many cases be found too lofty and too elaborate. Where ground is plentiful and cheap there are great advantages in the erection of one-storey buildings. From the plans of such schools the staircase of course disappears, some of the other arrangements become simplified, and the construction becomes altogether slighter. Country schools are however so familiar a subject to others, that I believe I may more profitably employ the remaining time, if I turn from them to a newer subject, one bearing upon the elementary schools of the future, and the middle class and the higher schools of the present. I allude to the class-room system, or, as it is often termed, the Prussian system.

If this is a departure from the programme of the paper, I trust it will be pardoned me on the ground that the application of this system to elementary schools is a subject with which I am to some extent identified. Members reading papers here, have generally, I believe, striven to select those parts of their subject (where a large field is open) upon which their own special studies or personal experience enable them to communicate information, which may at least have the value of not being readily accessible from other sources; and it is in conformity to this principle, that I invite you to consider for a moment, the models to which almost all large schools above the level of Elementary Schools, are now conforming, and upon which I believe the Elementary Schools of the future may in all probability be shaped.

The Schools of Prussia are perhaps the most complete to be found on the Continent of Europe, but those of many countries are formed on the same model. Collective teaching is exchanged in these countries for completely separate instruction; though a means of assembling a considerable proportion of the children together are generally though by no means always retained. So many classes, so many class-rooms is the rule; and an infants' department is not found in these schools. The maximum number recommended in a room is 60, 70 being considered an exceptional number. The class-rooms are oblong; it is indifferent whether they be lighted from the end or the side, but they must be lighted from one side only, and the children must have the light on their left hand. There seems no limit to the depth from front to back of a block of seats, but the length of each bench is so limited as to allow the master to inspect every child's work from the end of the bench. For the purpose of facilitating this inspection, a gangway is preserved all round the block of children, narrow at the back and at the side nearest the windows, but made wide enough next the wall facing the windows to be convenient for the ingress and egress of the children; and the block of seats is broken up into at least two masses by an additional narrow gangway from front to back. No child ought to be more than 30 ft. from the easel where diagrams, &c., are shown, and it is recommended that, as far as possible, the seat most remote from the window be not further from the wall than 1½ times the height of the top of the window from the floor.

The master's desk, on a slightly raised platform, faces the block of children; an easel for the display of diagrams, &c., a book-closet, and the stove or fireplace, occupy the space on either side of him.

These class-rooms are ordinarily put together so as to form a compact oblong block of buildings several stories in height, three stories being usually met with, and are frequently divided on plan into three portions by two staircases extending from front to rear: one of these is for boys and the other for girls.

These staircases, however, often occupy the end of the block, and sometimes a corridor connects them together; but this is sometimes omitted.

On an upper floor, and between the two staircases, is placed the Aula, or general room, calculated to seat about half the number of children provided for in the class-rooms. This room generally receives some amount of architectural decoration ; it is not customary for it to be divided by movable partitions or other means when not in use for collective teaching. Private rooms for the teachers, and sometimes one or more consultation rooms, complete the essential parts of the building, which is heated and ventilated on a general system.

It is recommended that as far as possible the class-rooms shall have a sunny aspect, and also, to secure greater freedom from noise, that as many as possible of them shall face the playgrounds rather than a main road.

For the filling up of this outline, I must refer you to Mr. Robson's book. In it he describes and illustrates many of the best examples of such schools as they are found in Germany, Austria and Switzerland, and points out in what respect the system of teaching which has given use to them, is essentially different from ours. One of these class-rooms encloses within its four walls, a little school in itself, and the teacher of it must be prepared to manage the children and fit to instruct them without much support from without; a class in a English school room is, on the other hand, constantly entrusted to a young boy or girl, who could not go alone for two hours together.

The School in Jonson Street, Stepney, built for the London School Board, from my designs, conforms very closely to the programme of one of these German Schools, and is the only one on that model which they have erected. It accommodates the large number of 1675 children—of whom 575 are infants, occupying two Infant Schools on the ground floor, 560 are boys in nine classes, taught in eight class rooms on the first floor, one class being taught in the large hall, and 540 girls in nine classes occupying eight class-rooms on the second floor, and a gallery at the end of the hall.

The class-rooms were intended for 60 each, and measure 20 feet by 27 feet, and are so arranged as to form three sides of a hollow square, which is in fact the hall; this measures 75 feet by 40. Those class-rooms which are not entered from the landings at the head of the staircases, are entered from the hall direct (a side gallery being provided for this purpose on the upper floor). There is therefore, no corridor; an arrangement made partly for economy, partly to simplify supervision, and partly to secure a freer transmission of fresh air right across the building, than could have taken place otherwise. There are two staircases, one at either end of the building, and each staircase is double. The heating of this building, I have already described to you, and having visited it repeatedly when in use in the winter, I find that the ventilating arrangements suffice to keep the class rooms sweet.

I have pointed out that the progress of school building in the case of Elementary Schools has been in the direction of isolating a larger number of classes or class-rooms than before, and no doubt, better results will be obtained. It is believed by the advocates of the Prussian system, that if this be pushed further and every class be taught on its own room, a still higher result will be reached, that is to say, the children will get on faster, and a larger proportion of them will pass the examinations of the different grades with success. This is extremely probable, but the difficulty in applying the system to Elementary Schools, is that it requires a more efficient staff than our present system calls for, and that such staff is consequently more expensive. The teacher of a large class of children shut up with him in a room must be fully equal to their discipline in all emergencies. In a school-room a pupil-teacher is considered equal to much of the work of teaching because if his class begins to get into disorder, the head teacher is within call and can come and restore discipline; but it is fair to observe that the instruction he gives is not always likely to be of the most mature description. The pupil-teachers system may possibly not always be maintained in England. The Germans, and I believe the Americans, do not possess it, and even if we never see reason to discard it, there appears a probability of the present proportion between the number of pupil-teachers and of trained teachers being reduced. Even as it is, if a so-called Prussian school were so built as to allow the classes to be worked in pairs, the present allowance of teaching power would, I think, enable class-rooms, say for 50 each, to be provided with a certificated teacher between the two, aided by a sufficient number of pupil-teachers to keep the two rooms going satisfactorily.

If the annual expense can be so arranged as not to be greater than in the present schools, or if the results can be shown to be so much better as to justify such an expense as is unavoidable, a second objection which has been raised to the system remains to be dealt with. This is the supposed increased costliness of the buildings unless they are planned for such large numbers as few neighbourhoods can supply. There is room to doubt the correctness of this objection. The Stepney School cost £7. 9s. 1½d. per head, or if the architect's commission be taken into account, £7. 16s. 7d. per head. The average cost of London Board Schools has been stated at £8. 10s. (whether with or without architect's commission, I am not aware). This building therefore (which is very substantial), is sufficiently below the average to allow for some increase in expense, consequent upon building for smaller numbers, and still to leave it an average building. At Stepney, the infant's department is disproportionately small, but that defect is one admitting of easy adjustment. A more serious objection to the introduction of the system, than either the question of cost of teaching, or cost of building, is to be found in the doubt whether the collective influence which the principal teacher now exercises over the whole department would be kept up. This however, is a matter for which provision is made in the existence of the hall, which in English practice might well be made use of for all that collective teaching, and singing, which in an ordinary school takes place in the general school-room, as well as for public examinations, mustering, drilling, or inspecting the children.

Many elementary schools have certainly not as yet been built on this model, though a certain number exist, as for example the fine Jews' Schools in Bell lane, Spitalfields, and as applied to these buildings it is chiefly remarkable as the probable school of the future ; but even under that aspect it was I think, right that your attention should have been directed to the class-room system, as one towards which school buildings are likely to turn in time ; and you ought clearly to be made to understand what radical difference exists between it and the present system. In schools above the elementary grade we are however rapidly approximating to the class-room system of teaching and the class-room form of building. What are termed middle-class schools are now fast gaining favour, and when the children of the artizan can be taught by well trained teachers, in spacious well constructed buildings, with good play grounds, we cannot believe that those higher in social station, with every inducement to give their children that best of all gifts, a good education, will be long content to remain behind. For the middle-class school as now taught in England, the German model is and indeed long has been the true type : but in adapting it to English use, one or two alterations must be made. The most important point is to fix rightly the actual size of each class room. The Germans will tolerate seventy and consider sixty a normal number of pupils in one room. English school masters vary extremely in the notions of what sized class they can conduct with advantage. I know a head master of great ability who says he would readily himself undertake a class of eighty, but many teachers would prefer such small numbers as thirty or even less. Probably the best rule is that very small class-rooms are only admissible in schools, where the education is to be carried to a high pitch, and then chiefly for senior classes ; and that for an ordinary middle-class school from fifty to forty in a class room is the proper number. The building should be capable of thorough window ventilation as possible, and class-rooms laid along-side of the central hall with no separate corridor, afford a better opportunity for a thorough current of air, than the double row of class rooms on either side of a central corridor, which many continental plans exhibit. The three stories in height and the two staircases so often met with in German schools, will generally speaking, be useful in English ones of this description. The hall will give the means of collective teaching, and is I believe so used in those London schools of the class which now possess one. In the fine schools now erecting for the Merchant Taylors' Company, the hall appears intended for public occasions only, since, in addition to the class-rooms, two school rooms each capable of containing half the number of boys are provided. In these rooms, it appears, the junior and the senior schools will assemble respectively for such collective lessons as are desired; but the provision of these two school rooms in addition to a general hall, and the dining hall which has usually been found needful, will not in every case be thought requisite. Further I do not now propose to carry the subject. A new branch of it is presenting itself which it would be interesting to follow up, and to pursue till it led us to the consideration of higher schools, and even of colleges; but I must pause and not make the attempt to enter upon it now, or to consider that interesting group (embracing many of the best modern school buildings), our large boarding schools, such as the Commercial Travellers' School, or the Orphan Asylums. Even the limited portion of the field which has been treated, has only been gone over in a comprehensive way, and there are innumerable points of detail upon which it is to be hoped the discussion will throw fuller light than it has been possible for me to furnish.

The CHAIRMAN,—I am sure we are much obliged to Mr. Roger Smith for his very interesting account of the progress of school buildings, and for the practical suggestions he has thrown out. I see here gentlemen more or less connected with school buildings, and we shall be glad to hear any remarks from them upon Mr. Smith's paper.

Mr. E. I'ANSON, Fellow,—As no one else rises I beg to propose a vote of thanks to Mr. Roger Smith. He has given us a paper in his accustomed lucid and most agreeable style and full of information, and I have listened to it with the greatest attention. As the school house which is now being built at the Charter House has been alluded to, and as gentlemen are invited to state their experience, I would say a few words with regard to it. That is a school in which it is intended that a liberal education shall be given to the middle classes, and in which fourteen or fifteen experienced masters will conduct the classes. That has led in this school to an arrangement whereby almost the whole of the teaching will be conducted in class rooms. There is in connection with the school a large lecture theatre, capable of holding half the number that attend the school, and in addition there is one large room, which I hope will be a noble hall, in which, once every day, and on gala days for speeches and prizes, the general assembly of the scholars will take place. Then, this school is intended entirely as a day school for boys in London and the neighbourhood, and when they have assembled in the morning they will not be allowed to separate during the day, so that it is necessary to provide accommodation for their dining; and this it has been determined shall be kept out of the general school building, at a considerable distance from the school, and will only be used as a dining room for the boys who attend the school. This building is erected on the site of the Old Charter House, and we can only hope it will share the prestige of the school which has been so long established there. The ventilation will be carried out on the plan which has been adopted with considerable success at the Albert Hall. The air will be forced into the building by a fan at great velocity, which will carry the air by tubes through the whole building; and the heating will be by hot water pipes, heated at low pressure.

Mr. E. C. ROBINS, Fellow.—I rise with much pleasure to second the vote of thanks to Mr. Roger

Smith, for having afforded us the opportunity of reconsidering this very important subject. It is one which has been much discussed, but has never to my mind been more pithily treated than it has been this evening in Mr. Smith's admirable and interesting paper. I have read Mr. Robson's well illustrated book on School Buildings—it is an excellent work, and adds very much to our information upon such structures both English and foreign. His own conclusions are rendered the more valuable, because they start upon the basis of what is most required in school and class room for the fullest development of the teaching power employed, and do not attempt to achieve, what has hitherto been too commonly aimed at, viz., to make them useful for every purpose under the sun. With reference to classes, the tendency is rather to reduce than to increase their size, at least in secondary schools. In the case of the North London Collegiate and the Camden schools for girls, the classes for the latter, or lower school, number 50 in each, and for the former, or upper school, 30 in each. To every such class there are a properly qualified teacher and an assistant. It is thought very desirable that withdrawing rooms for about 20 of the class should be provided, which of course requires an additional area of accommodation, unless a part of the class room itself could be screened off. The area allowed for each scholar is from 10 to 12 square feet in each room. In comparing these with Board Schools, they present a collection of school rooms for 50 or 30, with an equal number of class rooms for the withdrawal of about 20 at a time, with a distinct aula or lecture hall, when a sufficient number of rooms cannot be occasionally thrown into one, as in America. I am unable to add more to what Mr. Roger Smith has said so well and so exhaustively. I have merely risen to say how very greatly I have been interested by the paper, and to thank the author for the information he has so agreeably imparted, and the trouble he has taken in its preparation upon a very short notice.

Mr. T. Chatfeild Clarke, Fellow.—I beg to add my word of thanks to Mr. Roger Smith for his able paper, because I have known a good deal of the work which he has referred to, and which is also treated of in Mr. Robson's book which I hold in my hand. The difficulties under which we have laboured have been not only those of classification, but also those of expense. Of course it has been felt by those interested in this work, that it is their duty to study the ratepayers' interests, not to go so fully into the question of classification as they would otherwise have desired to do; but I would say on their behalf (and it will, I am sure be satisfactory to Mr. Roger Smith to hear it), that it is felt by those who take the deepest interest in the school at Johnson Street, Stepney, that it is one of the finest elementary school buildings they have ever seen; and it will be satisfactory to the meeting to hear that it is felt, in the estimation of those who know something of this subject, to be a school *par excellence* of the highest and best character. I was one who urged from the beginning that the School Board of London should take upon itself this system of classification with regard to the instruction of the children. I considered from the beginning, and I am now more than ever of the opinion that the best education we can give is the cheapest. I went to Edinburgh to see the primary schools there, which are some of them worked on the very system which has been adopted at the Johnson Street School. In the Scotch schools I may state that there is no common hall at all, and in one at least of the schools they teach as many as 1,200 children in classes of the average number of 50 in each. The masters and mistresses take the children as Mr. Roger Smith describes, in the way of a separate school. They go from day to day, and from month to month, and they are under the eye and the care of the same master or mistress, whereby they acquire a thorough knowledge of the characters of the children; their capacity for instruction, and they are thereby enabled to devote themselves to the best interests of the scholars. I questioned the head master of one school as to whether or not he thought it would be wise in carrying out this system of education in London, to go back to the system which had hitherto obtained in the elementary schools. He said by no means, and his feeling was distinctly in favour of division by the class-room system. I urged upon the London School Board that they should erect one of these schools at least in every district of the metropolis, but the ground on which it was met was the great extra expense of the teaching power. Many persons have thought that to put one child a little older to teach another child is a great mistake, yet that is the system pursued to a large extent in the elementary schools throughout the Metropolis. I venture to think, with regard to infant schools, the system of teaching collectively to the number of 120 or thereabouts, is not to be in any way reprehended. I can see no objection to it; at the same time, I believe that the root of success in our elementary teaching in the future lies in this system of class-room division. I am glad Mr. Roger Smith has devoted so much thought to bringing out the whole features of the case, not only in this country, but also in Germany and America, where much the same system is carried out. In America, I believe, they go farther then we do with regard to the adaptation of class-room desks to the requirements of the pupils, it being a very general practice to give each scholar a separate desk—a plan which we did not venture to adopt in London on account of the increased space it would require. We are not wholly working up to the best methods of the day; but we have endeavoured to improve and increase the number of class-rooms, to augment the process of subdivision, and to improve the character of class-teaching generally. There is one room which we have in some of our schools, which as far as I gathered was not referred to in the paper. The London School Board have laid stress upon a drawing class-room, and that that should be properly lighted from the north. They also lay stress upon having good lavatories and cloak-rooms, and the provision of every kind of accommodation upon a more ample scale than formerly. There are one or two other points I should like to refer to. On the question as to the cost of the school houses, Mr. Roger Smith has rightly stated the average cost of the later built schools, but when the comparison is made as between the schools of the London School Board and the ordinary voluntary schools, it is scarcely a fair one. Our schools, in a large degree, have large play-grounds partly covered, some of them to the extent of three-quarters of an acre, which of course materially increases the cost of the schools, and it will be found that the buildings themselves are very superior to those of the ordinary voluntary schools, as indeed they ought to be, dealing as we do with a large amount of funds. On the whole, I form a somewhat different conclusion from that in Mr. Robson's book, which contains some rather deprecatory remarks upon the class-room system, particularly with reference to the Johnson Street school. I would venture to impress upon the meeting that that is the point to which the authorities, not only of middle class, but elementary education should devote themselves as the only efficient system. I have lately paid a visit to some of the first-class schools of the country—Clifton and others, and I would say, that the class-room system appears to me, to be the only efficient method of teaching. No efficient teaching can go on in the noise and disturbance of the common school, and the distraction arising therefrom, and the sooner we can persuade the authorities of the Education department to favour the class-room system, the more we shall advance the great work of education throughout the country. I am sure, we must all feel indebted to Mr. Roger Smith for having taken up this subject, and for giving us so excellent a paper upon it.

The CHAIRMAN. It is now my duty and pleasure to put the resolution proposed by Mr. I'Anson, and seconded by Mr. Robins: that the meeting do accord its hearty thanks to Mr. Roger Smith for the able and interesting paper he has read to us to-night.

The vote of thanks having been unanimously agreed to—

Mr. Roger Smith said, I have to convey my best thanks to the gentlemen who have so kindly proposed, seconded, and supported this vote of thanks, and to you gentlemen, for the cordial way in which you have passed it. It has never been my fate to read in this room a paper prepared so hastily as this has been, and I confess, I was dismayed as I read it with the wearisome amount of detail I have gone through. I have to thank you all for the great patience with which you have listened to it, and for the kindness with which those friends who have spoken, have referred to it. I have to express both surprise and gratification at the way in which, what has been to me, the most important point I have touched upon, has been received. I refer to the value of the class-room system in elementary schools. I almost expected that I should be attacked on all sides as advocating a system not to be thought of, for I believe public opinion is hardly ripe for it yet, but I am convinced the time will come when it will be found to be the right thing. At present, our elementary schools are endeavouring to do two things or more. This has been before now the misfortune of schools and school buildings. Some of us have had the task of designing school fittings which should be also useful for tables and desks, or have had to arrange schools which should serve also for temporary churches. We are similarly endeavouring at the same time to instruct children and to train schoolmasters and mistresses. I think the only way to carry the work out properly is to separate the one from the other. The children should be taught by skilled teachers, properly trained in training colleges, for the work they undertake. When that is done, and the pupil-teaching is at an end, there will be no obstacle in the way of teaching each class in separate class-rooms.

The meeting then adjourned.

Royal Institute of British Architects.

At the Ordinary General Meeting held on Monday, the 1st of June, 1874, JOHN GIBSON, Vice-President, in the Chair, the following Essay, for which a Medal of Merit had been awarded by the Institute on the 9th of March, was read:—

ON VAULTING.

By T. H. EAGLES, B.A., Associate.

THE influence (all important and all pervading) which the persistent and unwearied attempts of twelfth century builders to erect over their buildings a substantial and permanent covering of stone, had on the architecture of subsequent times, is now well known to all who have given any attention to the subject. It will probably be now admitted by every one that it was the working out of this problem which gave birth to almost all the distinctive characteristics of Gothic architecture, and the fanciful yet ingeniously supported theory that the "clustered and banded stalks of the lofty pillars, the curling leaves of the capitals and cornices, the interlacing arches of the fretted vaults" of the cathedrals of the Middle Ages, are attempts to reproduce in stone "the awful gloom of the deep forests of the north, the aspiring height of the slender pine, the spreading arms of the giant oak," must now be given up by all except the poetic "Quarterly Reviewer" who has the confidence to maintain that these glorious unities, these perfect wholes, were the result of a number of uneducated workmen each doing that which was right in his own eyes without consultation or superintendence.

It was, I believe, Ware, in his "Tracts on Vaults" who first shewed vaulting thus to be the *final cause* of Gothic architecture, but since his time the question has been more thoroughly worked out, notably by M. Viollet-le-Duc, who in his magnificent Dictionary in the article "Construction," says:—"The vault being from this time forward" (end of twelfth century) "the generator of all parts of a vaulted building, fixing the position, form, and arrangement of the supporting masses, is the first thing we ought scrupulously to study. By one who thoroughly understands the structure of the Gothic vault and knows the infinite resources its construction presents to view, all the other parts of the masonry can thence be naturally deduced."

Dr. Whewell, too, the late master of Trinity College, Cambridge, in his "Architectural Notes on German Churches," considers "that the adoption of the pointed arch in vaulted roofs arose from the requirements of vaulting, and from the necessity of having arches of equal heights with different widths," and further that "from its original situation in the vaulting, this form of arch was gradually diffused into every other part of the building." This view is indeed disputed by Professor Willis (whose admirable paper on the vaults of the Middle Ages renders the volume of the Institute proceedings in which it appears one of the most valuable of the entire series), for in the preface to his "Remarks on Architecture," he observes "There is a fascinating simplicity about that theory" (of the origin of the pointed arch) "which would derive it from the requirements of vaulting that makes one wish to find it true; but I am sorry to say that, notwithstanding the favourable prepossessions with which I set out, I have been compelled to dissent from this ingenious hypothesis. I have shown that so far from the pointed arch being necessary to enable a parallelogram to be vaulted, it appears that architecture was already in possession of several methods of performing this, which were not even superseded by the introduction of that form, but continued in use to the latest period of the Middle Ages." These methods are of course those which prevailed among the Romans, and which are now known as Roman vaulting; but the vaults constructed on these principles (to which I shall refer more particularly directly), are kept up and maintained in equilibrium solely by the inert mass of the supporting piers, the area of which is very large, and which, thanks to the splendid quality of the mortar used, so good as to have become proverbial, are practically homogeneous throughout, the cohesion being perfect. This was indeed the principle of Roman building. The Romans secured stability by the sheer weight of the resisting portions of their buildings; if, for instance, they feared that an arch would rise at the haunches unless an enormous load was placed there, instead of seeking a more scientific form of arch they simply piled on the required load, and so for the rest.

Now it was not only possible but easy for the Romans, a powerful people, possessed of abundant means and appliances, with armies of labourers, with any quantity of materials, and above all with a great love of show and display, both of their wealth and power, to build in this manner. Economy was to them no object, but when we come to the twelfth century, to people just emerging from the barbarism and ignorance and consequent poverty of the centuries following the downfall of the Roman power, the case was altogether different. At first, indeed, they seem to have attempted to imitate the structures which the barbarian incursions had spared (for I should notice that it is to the continent we must go for the earliest mediæval examples), but they speedily found the impossibility of continuing this method. With them the most rigid economy had to be practised, the utmost possible effect had to be produced with the materials used, nothing could be laid to waste, and therefore instead of relying on mass and mere weight, the thinking faculty had to be exercised, and so attempts which were gradually though doubtless only after repeated trials and occasional failures, crowned with success, were made to balance opposing forces, to diminish thrusts and pressures, and to make the direction of these as vertical as possible, thereby simultaneously enabling the area of the piers to be safely reduced.

These circumstances, I think, acting on the ever present desire in the twelfth century for stone vaults, led directly to the results produced, and furnish a reason why the previously existing Roman solution of the problem could not be accepted, as well as an answer to Professor Willis's objection to the theory in question. The question why stone vaults were so much sought after in spite of all the difficulties attending their construction, and why the builders of the day were not satisfied with wooden roofs, is a difficult one to answer. Probably the danger which there always was in those unsettled and turbulent times of the malicious or accidental destruction of any important building by fire, had something to do with the matter. Certain it is that such an event was by no means uncommon, and the use of the more durable and permanent material was thus perhaps in a manner forced upon the designers; for there can be no doubt whatever that a brick or stone shell over a building, whether the same be the actual roof or not, renders it to a very great extent fireproof. Even where (as is almost universally the case) the vault is only a sort of inside ceiling, and is protected from the weather by a timber-framed roof above, a careless plumber can do very much less damage than where in place of the vault there is only a wooden or plaster ceiling, for by cutting off air from below, the fire is checked and more easily mastered, as was strikingly exemplified at Canterbury at the time of the fire there in November, 1872, for though nearly two hours elapsed between the breaking out of the fire and any water being brought to bear on it, still it was confined to the eastern limb of the cathedral (where it commenced), and as the burnt and charred timbers fell in on the upper surface of the vault, and so were prevented from dropping into the choir below, scarcely any damage was done to the interior of the building.

It is not too much to say, then, that the existence to-day of this precious national monument is mainly due to its "stone ceiling," a very good reason for recommending similar construction where a durable building is required. On the other hand, York Minster, which is covered with a wooden ceiling, of sham groining, has twice within the present century suffered most severely from the ravages of fire.

In 1829, the roof, the whole of the richly carved tabernacle work of the stalls, and in fact all the woodwork of the choir were utterly destroyed, and it would be easy to multiply instances.

Every one knows, however, that in England it was by no means the universal custom to ceil a building with stone; but if we compare the circumstances of our own country and those of our continental neighbours, I think we may find reason for the greater prevalence of vaults there than at home, and which is of course another cause why the difficulties of vault construction were so steadily struggled against, and the system so pertinaciously adhered to. Our noble open timbered roofs are legacies of which we may well be proud, which have no rivals abroad, and which we owe in no small degree to the magnificent forests of oak trees for which England was formerly famous. The Romans seem to have drawn heavily on the forests of Gaul after those of Italy were exhausted, for timber for their immense naval and engineering works, and hence even as early as the middle of the twelfth century, the provinces where the first glimmerings of returning civilization had appeared, and where consequently architectural art was most advanced, appear to have been almost entirely cleared, and as a natural consequence wood became a comparatively scarce and proportionately valuable material.

Whether this be the explanation or not, we have abundant evidence to shew that vaulting had advanced a very considerable way towards perfection on the continent at a time when it was very little if at all practised in England, that it was then imported, so to speak, complete as it stood, and that it throve so well after being transplanted as soon to surpass its parent stock both in beauty of design and careful execution; no continental examples, indeed, can compare with the richness and skill displayed in some of our late ones, though it may be doubted after all whether these last may not be adduced as instances of the "vaulting ambition which o'erleaps itself."

I do not propose to enter into any discussion as to the antiquity or invention of the arch. Many of the so-called examples of its early use would be very much to the point if it were not for the unfortunate circumstance that they in no way exhibit its principle, but consist only of a series of corbelled out courses with horizontal beds—a method impossible of application to the covering in of extended areas. It is enough to go back to the days when Rome became a mighty nation, and was enabled to indulge in those tastes to which I have already referred. The occasion of the rebuilding of the city after the burning by Nero, seems to have been taken advantage of for covering in many builldings with vaults, which, until then, had only wooden roofs; and none of the great vaults with which we are acquainted seem to be of earlier date than this.

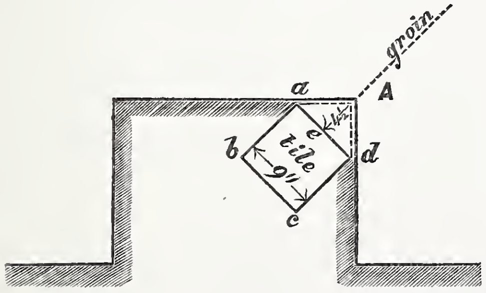
Until comparatively recently a totally erroneous notion appears to have prevailed, at all events in this country, as to the Roman method of construction. The general idea was, I think, that their vaults were either of solid masonry accurately cut and worked; or were composed entirely of *béton* heaped over centering, heavy and substantial enough to resist the enormous weight necessarily lying on it until the closing in at the crown, and "setting" of the concrete rendered the mass self supporting. Recent investigations, by M. Viollet-le-Duc and M. Choisy, have, however, thrown fresh light on the subject, and shown that the real mode of procedure was very different. M. V.-le-Duc tells us that we find with difficulty even one or two examples of groined vaults of wrought masonry in ancient Rome. From motives of economy they avoided the interpenetrations, groin ribs, wrought pendentives, etc., of modern architects; and M. Choisy (*Encyclopédie de l'Architecture*) says "As to *béton* the ancients certainly knew the use of it, since Vitruvius describes it as being proper for sea walls or other marine works, but from an examination of ruined buildings remaining, it is evident that its use was by no means so general as is usually supposed." Both these gentlemen have proved that the active principle in Roman vaulting is economy in the wooden centering used during the construction, but of no permanent use in the building. This centering is always a most important item in the cost of a vault, and though the

Romans lavished immense sums on the *decoration* of their buildings, their love of display would lead them to view with disfavour any system requiring that a considerable portion of the cost of a building should be as it were hidden from view, sunk in mere temporary scaffoldings, or wasted on complicated stone cutting unnecessary for producing the effect required. Instead, then, of solid masonry or *béton*, we find in most cases that their vaults really consist of ribs of brickwork thrown across at intervals, at right angles to the axis of the vault (exactly similar to the transverse ribs or arches of the subsequent Gothic ones); that these are connected at intervals by courses of the well known large flat Roman bricks or tiles, the edges being horizontal, but the sides lying in planes passing through the axis of the vault; and that the spaces between the various members of this skeleton framework (a series of squares or rectangles) are then filled in with light concrete, the weight of which, even before it finally solidifies, is not thrown entirely on the wooden centering, but is carried to a very great extent by the skeleton or framework of ribs. The economy which this system introduces into the centering is obvious; instead of a solid platform being required, along the whole length of which the weight and pressure would be everywhere equal, necessitating equal strength everywhere,—and consequently rigidly framed trusses in close succession, covered with enormously thick planking,—all that was necessary was a framed truss under each of the transverse ribs, and comparatively thin planking for the intermediate fillings in, which were of relatively light construction. Viollet-le-Duc, in a series of instructive sketches, exhibits this construction; and shews how here and there, as the transverse arches were turned, pairs of bricks were made to project sideways beyond the general outline of the rib, between which a plank might be dropped edgeways for the temporary support of the connecting horizontal courses. It would further appear that in order to still further lighten the necessary centering, the first step in the construction of the vault was frequently the laying a thin shell, as it were, of tiles flat over its entire area, which in fact, became a permanent centre on which the vault could be completed. This shell, of course, would not be self-supporting in the sense of remaining stable if its centering were struck, yet it would certainly take off from this last a very great deal of the subsequent superincumbent weight, more especially of that of the upper half of the vault, since its stability would be immensely increased by the filling in over its haunches. The importance of this can scarcely be over-rated, since it is precisely this portion which bears most heavily on the centering, *i.e.*, until the keystones are driven, necessitating, of course, large scantling for the timbers used, and very judicious trussing in the supporting frames. It is hardly too much to say that for a vault constructed as above described, the centering need hardly be stronger than is necessary for the support of the workmen employed—excepting, of course, as regards the trussed centres for the transverse arches,—and the risk of deformation of the centering with all its attendant evils is reduced to a minimum, or rendered of very slight importance.

There are one or two examples of Roman vaulting consisting of a series of parallel transverse arches within a short distance of each other, on the backs of which thin slabs of stone are laid, connecting them together in pairs and completing the covering. (Figs. 1 and 2, Pl. III.) This system, too, obviously favoured economy in the centering required, as continuous planking might be dispensed with altogether; but it was quite exceptional, the transverse arches being generally hidden in the thickness of vault. There is certainly in many points a striking analogy between it and the rib and panel vaults of a subsequent period.

The foregoing remarks refer strictly only to what is known as a continuous barrel vault. This is what the majority of Roman vaults were; semicircular, of course, in section; in fact, in appearance exactly like the upper half of most of our railway tunnels. Interpenetrations seem to have been avoided, at all events until the later days of the Empire, and if from the necessities of planning, an art in which the Romans seem to have been great adepts, a vault had to abut end on to the direction of another, they frequently got over the difficulty by making one (the smaller of the two) at a lower level than the other, so that the springing of the larger one would be above the crown of the other—the minor vault would finish as a semi-arch in the vertical abutment wall of the superior. We know, however, from existing remains, that the Romans did not entirely shirk interpenetrations of curved surfaces, and this really brings us to the difficulty of the subject—*groined vaults*. If we have to cover in an exact square, there is obviously no reason why we should choose one pair of sides for direction of axis of our barrel vault, more than the other; at least, if we are not hampered by any considerations of convenience in securing the necessary abutment: in fact, we might suppose a complete barrel vault to be turned across in each direction, and, supposing that the two could co-exist, the space below would obviously have a *double* covering. Now if we imagine the part of each vault which is *above* the upper surface of the other cut away, we should have remaining a sort of square dome, which would form a *single* covering over the entire space; while if we cut away the part of each vault which is *covered* by any part of the other, *i.e.*, which is *below* its under surface, we should have a roof with salient edges or groins over the diagonals of the compartment, and which no longer abuts continuously along its sides, but the entire thrust of which is transferred to the four angles, and which might be carried on piers there placed. Both these methods were used; the first is known by French architects as a vault "*en arc de cloitre*," the second is the ordinary "*groined Roman vault.*"

Thus far all is plain sailing; the compartment to be vaulted being square, the diameters of the arches on each pair of sides (the generators of the respective vaulting surfaces) are equal to each other, the crowns intersect in the centre of the compartment and the groins are plane curves. Each being only an oblique section of a right circular cylinder, its outline would be a semi-ellipse, and by constructing wooden centres to this outline, arches could be thrown across from angle to angle of the space to be vaulted, and the entire vault could be completed exactly as before described; the only requisite to be observed being that the centre should be so much larger than the actual finished groin, as the breadth of the tiles used required in order that their angles should not project beyond the finished vaulting surface. Thus, supposing the accompanying sketch to be the plan of a pier between two square compartments at the springing line of vault, the finished groin line starts from *A*, but if tiles say 9 in. wide were used for the diagonal arches, the first one would be laid in position *a b c d*, and the distance *A e* would be at least 5 in., *i.e.* the major axis of ellipse used for the centre would be at least 10 in. more than span of finished groin line—the triangular space *A a d* would be, after completion of vault, dubbed out and made up with plaster.



As soon, however, as we attempt to cover in a parallelogram with a groined vault difficulties beset us, which are the greater the more the parallelogram departs from a square. The sides being unequal, if we use barrel vaults semi-circular in section for the generating surfaces of our groined roof, we cannot at the same time have the springing line and crown of the smaller, level respectively with the springing line and crown of the larger; but if we make both spring at the same level the crown of the one is below the crown of the other, while if we make their crowns level the springing line of the smaller is more or less above that of the larger. In both these cases the groins are no longer plane curves. In the first we get an intersection of which fig. 3 is an isometrical view, and whose plan is shown by the lines *a e d*, *b e c* of fig. 5; *a b c d* being the plan of a compartment whose sides are in ratio of 2 to 1; *b f c* in the same fig. is the elevation of the smaller vault, and *c g h* half that of the larger; and the groin leans over, making it impossible to turn an independent arch to carry it; while in the second the smaller vault has to be stilted, and the groins project in plan into the wavy lines *a k c*, *b k d* of fig. 5, (*see figs.* 3, 4, *and* 5, *pl. III.*,) and the construction of an independent arch becomes equally impossible. Notwithstanding these difficulties, vaults were constructed with these groins of double curvature, notably over the great hall in the baths of Diocletian, now the church of S. M. degli Angeli, but the compartments do not differ greatly from a square on plan, the sides being as 4 to 5, and the span 67 feet; yet even here the effect of the twist in the groin is, by universal testimony, exceedingly disagreeable to the eye, and causes a painful sense of insecurity. In the great hall of the baths of Caracalla the mere springing of the vault remains, yet there are clear indications of the twist; the proportions of the sides of the compartments here are as 9 to 11, or a trifle more nearly square than the preceding. In consequence of these difficulties and objections, Professor Willis, in his "Remarks on the Architecture of the Middle Ages," observes, "it is no wonder that a new expedient was soon found to supersede it," (the twisting groin) "which appears to be the domical or inclined form of the vaulting cells." (The vaulting surfaces filled in between the supporting arches or skeleton framework.) "The whole difficulty of vaulting a parallelogram with quadripartite vaulting, resides in the assumed necessity of preserving the apex of the vaulting cells horizontal, and making their surfaces cylindrical throughout. If we free ourselves from these conditions it is easy to show that we can not only vault any parallelogram or trapezium, but that we may make both arches and groin of any figure we choose.

"For let *A B C D* be the parallelogram, and let there be set upon each of its sides an arch of "any figure, having the diameter of each respectively as *A a B*, *B e C*, *C c D*, *D d A*, and upon the "diagonals *A C*, *B D* other arches *A V C*, *B V D*, which must intersect at some point *V*. (*See Fig.* 6, *pl. III.*)

"Then to complete the vault we have only to cover each triangular portion *B a V*, *A a V*, *A d V*, "&c., with a surface, which is always possible however the curvature or inclination of their sides may "differ; but the ridge line of each cell, which may be curved or straight, will of course be more or less "inclined according as the apex of the lateral arches is more or less below or above the intersection of "the groin ribs. In fact, this reasoning is entirely independent of the form of the arches, and bound "only with the one condition, that the diagonal groins must intersect in some point, and therefore gives "a complete solution of the problem with semi-circular arches only. Pointed arches might naturally be "used instead of semi-circular ones, after their discovery or introduction, and their convenience and "strength would occasion them rapidly to supersede the latter. But that there was no *necessity* for "their employment is clear, because this expedient of forming domical cells was known to the Roman"esque builders and used by them at Spires, and other examples of the same age, before the pointed "arch made its appearance. Nay, I am by no means certain that it was not employed earlier, for I "have already shown that domical cells are to be found at Baiæ, in the temple of Venus, and elsewhere, "although I am unable to cite an example of them in a genuine Roman cross vault."

The roof of the above mentioned temple of Venus, however, it should be noticed, is a genuine dome on a cylindrical supporting wall, and not a vault over a rectangle.

Summed up in the above short description we find noticed the introduction of a principle of the greatest, in fact of quite cardinal importance in the construction of vaults. It is the vital point of difference between Roman vaults and those of the middle ages; introduced by Romanesque architects in a tentative sort of way, it was developed by them to a considerable extent, but could not get full scope while they were restricted to the use of semi-circular arches, and, I believe, the pointed arch followed naturally from the attempts that were made for its perfect development. It will be noticed that in the

Pl. III

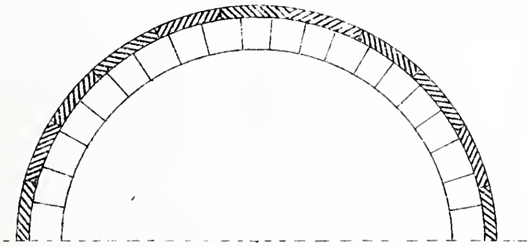


Fig. 1

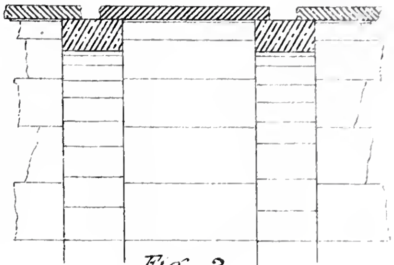


Fig. 2.

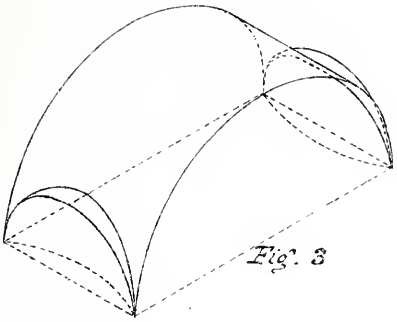


Fig. 3

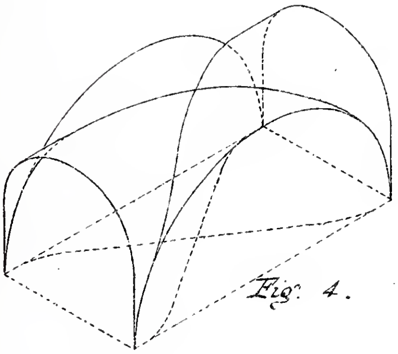


Fig. 4.

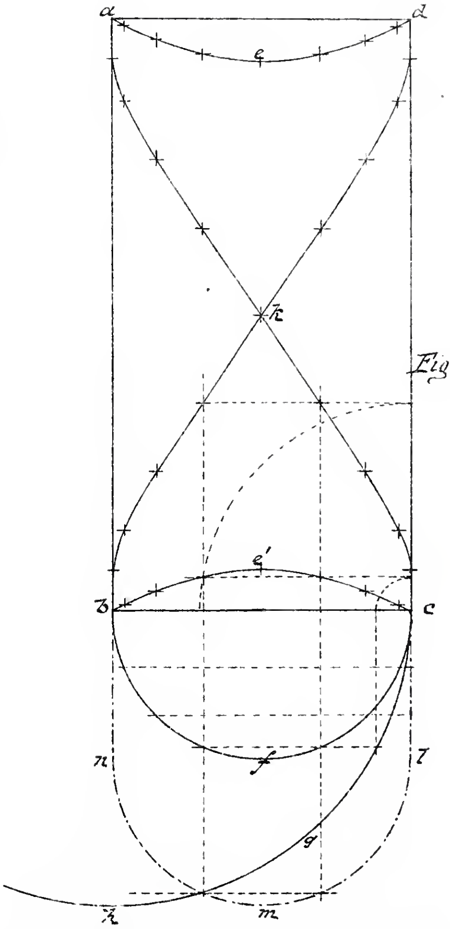


Fig. 5.

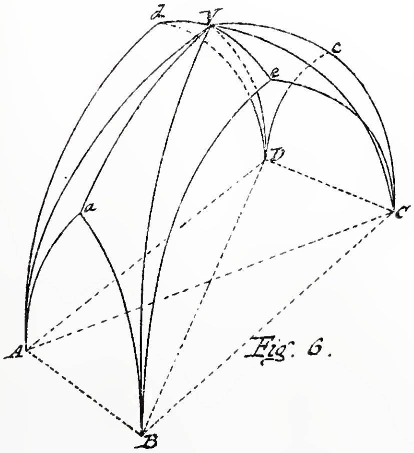


Fig. 6.

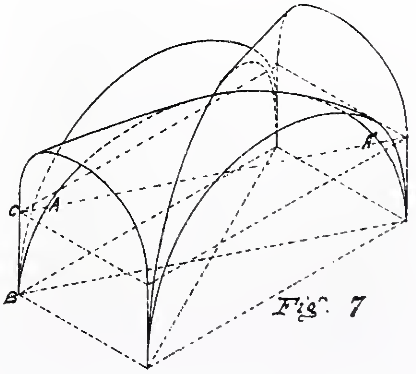


Fig. 7

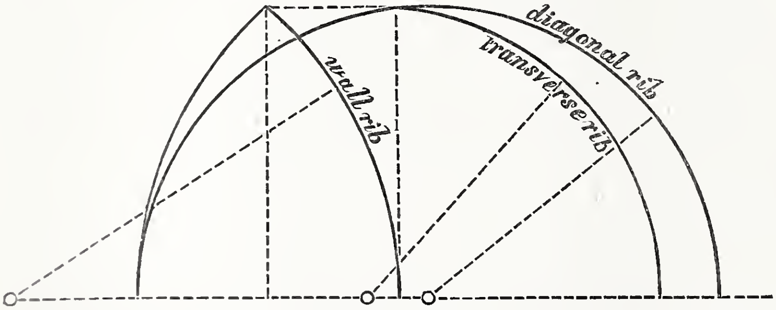
Photo-Lithogd for the R.I.B.A. by C.F. Kell, London

genuine Roman vaults the vaulting surfaces are of the first consideration, and the groins are merely the result of simple interpenetration of two or more cylindrical surfaces; this followed naturally from the minds of their architects being pre-occupied with the simplest possible form—the semi-cylindrical continuous barrel vault; and the change to which Willis refers was certainly not so simple a one to make as he seems to imagine, and was never adopted by Roman, as distinguished from Romanesque, architects at all. Between the building of the baths of Diocletian and of the cathedral at Spires was an interval of nearly 700 years. The new principle introduced was of course that of making the groins regular curves, in no way dependent on the curve adopted for the vaulting surface over the sides of the compartment, and adapting the surfaces of the intermediate vaulting cells to the outlines thus given to the "skeleton" framing of the vault. In the Roman method the vaulting surface was everything; it was made perfectly regular; the groins were subsidiary, and as it were an accident of the construction: in the new method the groins were of equal consideration with the bounding curves over the sides of the parallelogram, and the intermediate filling in became of but secondary importance. The true key to the solution of the problem of vaulting construction had now been found, a new path had been opened by travelling along which most of the difficulties that had beset previous efforts were avoided, and an impetus was given to the art which produced the happiest result. Working on this method, nothing, in the words of one of our greatest living architects, "is simpler than a good vault. The "best rule for it, is to make a good diagonal arch and a good transverse arch, and the filling in of the "cells is pretty sure to take care of itself." The pointed arch was still, as I have said, necessary for the perfecting of the new method, and for this reason: In a rectangle, the sides of which are say as 2 to 1, the semi-circular arch on the diagonal (*i. e.* the groin arch) will be more than twice the span of the semi-circular arch on the short side, (the wall arch), and hence if we make these arches spring at the same level we must have a piece of dead wall (in height more than half-span of side arch) in order to raise the side walls of our compartment to the level of crown of diagonal arch. In order to allow the tie-beams of the sheltering roof to clear the vaulting the side walls obviously had to be raised to this level, and hence the adoption of this method required an expenditure of labour and materials producing no adequate effect, which could not but be distasteful to builders possessing only such limited resources as did the early Romanesque builders of France and Germany. If on the other hand the crowns of the side arches were raised to the level of those of diagonal ones (*i. e.* if the side arches were stilted more than half their span) it would follow that a horizontal plane through springings of side arches would cut the diagonal arches in *A* and *A*, (*fig.* 7, *pl. III.*), and the vaulting surface from *B* to *A* would have to be skewed and twisted between the vertical line *B C*, and the curve *B A* in a very peculiar manner.* The same objection would apply if we made the diagonal rib segmental, *i.e.*, if we made its rise equal to half-span of side arch, and in addition there would arise the awkwardness and unsatisfactory effect of the arch starting out of its pier at a decided angle, instead of growing gradually out of it in the manner so distinctive of perfect Gothic. All these methods and combinations of them were, however, adopted in the earlier days of the Romanesque period, the latter half of the XIth, and the whole of the XIIth century; but an expedient which perhaps obtained more favour than any other was the following:—The difference in the rise of the diagonal and side arches is less when the compartment is square on plan than when it is any other rectangle; the naves of early Christian churches were generally made almost exactly twice the width of the side aisles, and the span of the arches of the nave arcades was equal to width of aisles, hence the aisles were made up of a series of squares on plan, and the vaulting there was comparatively simple; then, in order to get square vaulting bays in the nave, two compartments of the nave arcade were taken in to form each bay, and the diagonal arches were consequently supported by *alternate* piers, the distinction between those which carry both nave arcade and superior vaulting, and the intermediate ones carrying arcade only, being variously marked. "This mode of vaulting with semi-circular arches both ways and with "no diagonal ribs, is still found in several ancient churches, though it has often been replaced by "more modern vaults. It is found with considerable dimensions in the churches of St. Maurice and "St. George, at Cologne; the ancient monastery churches of Laach near Andernach, and Eberbach "near Elfield; and on a still grander scale in the gigantic cathedral of Spires, where the span of "the vault is about 45 feet; and though the storms of war have so often and so fiercely burst upon "this city, it is confidently asserted by the most learned antiquaries, that part of the vaulting is of "its original form. In most of these instances, and especially at Spires, the compartments are considerably *domical*, the intersection of the diagonals being higher than the summits of the bounding "arches."*

---

* In vaulting of all periods we frequently, indeed generally, find the wall rib stilted, and a consequent twisting of the vaulting surface, but the height of the stilt is much lessened by the use of pointed arches; by its use excessively acute arches are avoided.

The method, however, can only be deemed an expedient, and an evasion rather than a solution of the problem of how to vault over a parallelogram.



The pointed arch alone enables this to be completely and satisfactorily accomplished, as with it we can make an arch of any span and any height. Suppose we have to construct a groined vault over a rectangle 40 ft. by 20 ft., the length of the diagonal will be 44 ft. 8 in. nearly, and a semi-arch described on it will rise about 22 ft. 4 in. If we decide to make our ridges level, the arches over the sides may be made of the following forms:—The transverse arch may be struck with the same radius as the diagonal, and the radius of the wall arch (over the short side of the rectangle) will be 30 ft. There is here no waste of space, the filling in of the spandrels is simplified, and the construction is comparatively easy. We have now reached a stage when a fresh feature is introduced.

In genuine Roman vaulting the ribs were, almost without exception, hidden in the thickness of the vault; the filling in was packed in between them, and the intrados, or under surface, was flush from one end of the building to the other; it became a homogeneous crust without elasticity, and which ruptured, if by chance there was any settlement of the walls; but the very earliest Romanesque builders seem to have aimed at securing a certain amount of elasticity in their structures (which indeed economy imperatively demanded), and their vaults were formed of shallow courses of unhewn stone, bedded in mortar, but arranged as *quasi* voussoirs. To stiffen these shells, transverse arches were turned across from pier to pier; but instead of being hidden in the thickness of the vault, they were built *underneath* it, appearing as projections from the general surface, and forming a permanent centering. These are referred to by Whewell in the quotation just given, and on reference it will be seen that he also points out that similar arches run from pier to pier along the clerestory wall. This was a further carrying out of the elastic principle; obviously by it the whole weight of the vault was carried directly by the piers, the clerestory walls being relieved of all pressure from it, and these arches could follow any small motion of the piers, accommodate themselves to their settlement or spreading, while the concavity of the masonry shell above them could still be secured. To carry the principle to perfection, the groin or diagonal arch obviously required to be made to project like the transverse and wall arches, and then we get the full complement of projecting ribs, and the great æsthetic principle of the constructional parts being made visible and prominent was fulfilled. We have now perfect *quadripartite* vaulting, so-called because it will be seen there are 4 vaulting compartments or cells in each bay, the development of each of which is a sort of triangle.

---

* Whewell's "Notes on German Churches."

The introduction of visible ribs was the cause of a somewhat singular modification of the method already noticed, in which 2 bays of the nave arcade were taken to form each bay of the main vault. It was felt, I think, desirable to remove, if possible, the inequality which necessarily existed between the alternate piers of the nave arcade. To effect this, transverse ribs were thrown across between every pair, but the diagonal ribs were turned precisely as before, and each pair consequently not only intersected each other, but also the crown of the alternate transverse rib. This transverse rib could not be left, a mere stone arch supporting nothing, and at first probably a vertical wall was built on it up to the crown of the vaulting cell, resting on the diagonal and wall ribs. An instance of this still exists in the Abbaye aux Dames at Caen, but a subsequent improvement was to make the wall ribs one instead of 2 bays of the nave arcade in span, thereby forming in each complete vaulting bay *six* compartments or cells, the ridges of which would radiate from the centre of the bay to the crowns of the 4 wall and 2 *main* transverse ribs respectively ; the 4 cells abutting on the clerestory walls being of course unsymmetrical about the vertical planes containing their ridges. There are numerous examples of this method—notably the Abbaye aux Hommes at Caen, contemporary with the Abbaye aux Dames ; and in our own country the Choir of Canterbury. It may not be without interest to notice that in Sir G. G. Scott's competition drawings for Edinburgh Cathedral, the choir is shown vaulted in this manner, which, from the number of cells in each bay, is known as *sexpartite*.

With the introduction of the pointed arch and the thorough admission of the principle above mentioned, the making the ribs a sort of permanent centering on which the filling in could be laid, the principal difficulties of vault construction may be said to disappear. Much of course remained to be done, but chiefly only affecting matters of detail, which the practical experience gained by every building raised, tended largely to explain and show how improvement might be made. Such a point was the starting the ribs from the supporting pier.

At first a single vaulting shaft ran up the face of the clerestory wall—generally from the nave floor level, being attached to the nave pier, though sometimes starting from its capital or from a corbel in the spandrel between the nave arches, and on the abacus of this single shaft had to be found room for the springing of the transverse rib, the 2 diagonal ribs and the 2 wall ribs, though these last would appear to have been frequently omitted. At first no attempt was made to make the various ribs mitre or penetrate into each other, but each started independently from the supporting abacus.

Fig. 1 Pl. II is a plan at level of springing of a very Early Anglo-Norman vault—that of the chancel of Upton Old Church, near Slough, Bucks ; and fig. 4 is a detail of the part A. The transverse rib, it will be seen, is a single square-edged member, 14 in. wide, while the diagonal ribs are decorated on the face with a large and heavy moulding semi-circular in section. The peculiarity of the arrangement is, that the ends of the diagonal ribs, abutting on the transverse ribs, are not completely detached from the wall, but are partly buried in it, as shown by the dotted lines ; and the reason obviously is to reduce as much as possible the projection of the supporting capital. The part of the rib shown by the dotted lines of course makes its appearance out of the wall surface some

distance above the springing, the wall plastering finishing on the rib in an extremely haphazard way; and the rough and ready manner in which the whole thing is managed, is the more evident since the other extremities of the diagonal ribs are entirely clear of the wall, as shown at B, fig. 1.

It will be noticed that the chancel is only two bays in length, and that there is consequently only one transverse rib, viz. that dividing the bays. There are no wall ribs, but the vaulting surface abuts directly upon the walls north and south, east and west: the intersecting curves on the north and south walls are semi-ellipses, the major axis being vertical as shown at fig. 3; and the cells are slightly domical. It is worthy of notice that the two halves of one of the diagonal ribs are not exactly in the same plane, but that apparently the rib A B was turned first, and the rib C D in two parts abutting against it, as shown at E. The transverse arch is semi-circular and slightly stilted (the stilt 8 in. high), and the diagonal ribs are segmental, the centre being one foot below springing line, and the radius 9 feet. The former is carried on a column with ordinary cushion capital, and the latter on corbel capitals, as shown by the sections, figs. 2 and 3.

The necessity for providing a large area for the seating of the springers of the various ribs frequently led to separate shafts being provided for the support of each rib, which thus each had a separate capital from which to spring. We have here obviously the first germ of the clustered pier. A very early example is given us in the nave aisles of Peterborough Cathedral. The nave is covered with a wooden roof, and was probably never intended to be vaulted, since shafts for the diagonal ribs are only provided next the aisle, while the half shaft towards the nave, instead of stopping at the string under clerestory windows, which would be the springing line of the vault, is continued right up to the string over the clerestory window arches, and there finishes abruptly. The tie-beams of the original roof probably rested on them, though these have of course disappeared. I was unable to get the exact curvature of the ribs of these aisle vaults, but the transverse ribs are semi-circular and considerably stilted, while the diagonal ribs are segmental, with their centres some distance below the springing line. The effect of this is to throw the diagonal ribs forward, so that looking down the aisle, part of each transverse arch is cut off as it were by the diagonal rib in front of it; and in order to avoid excessive twisting of the vaulting surface, each diagonal rib has to have a backing piled on its *extrados*, upon which, as on a centre, the actual filling in is laid exactly as noticed by Professor Willis in the castle at Newcastle-upon-Tyne, and in the ruins of Finchall Priory, Durham.

The transverse rib consists of two rolls, with a V shaped member between them, while the diagonal ribs are exactly like those of the preceding example.

The next great improvement consisted in making the ribs run into or penetrate each other. This of course greatly reduced the area of the vaulting springer, and, consequently, also, that of the supporting pier. As the principle, too, of Gothic vaulting was worked out, and the logical consequences of that principle were freely and fearlessly followed and admitted, we find a change in the general outline of the ribs. Hitherto their breadth (the dimension seen on plan) has been greater than their depth (the dimension below the vaulting surface); but since the stability of the vault depended on these ribs, which were, in fact, a series of independent arches, a reversal of these proportions was the necessary and logical result of a due consideration of the property of the arch "that its stability increases with its depth." Hence, we get, from such outlines as those already given, to such as that given in Fig. 9, Plate II. This, too, assisted in the *concentration* of the ribs, so to speak, on the supporting abacus. Careful management is required to make the various ribs *mitre* into each other properly. With ribs of various curvature, we are liable to find some particular one disengaging itself from the spandrel solid before its neighbours, which introduces a certain amount of awkwardness. This is

Pl: II UPTON CHURCH. BUCKS.

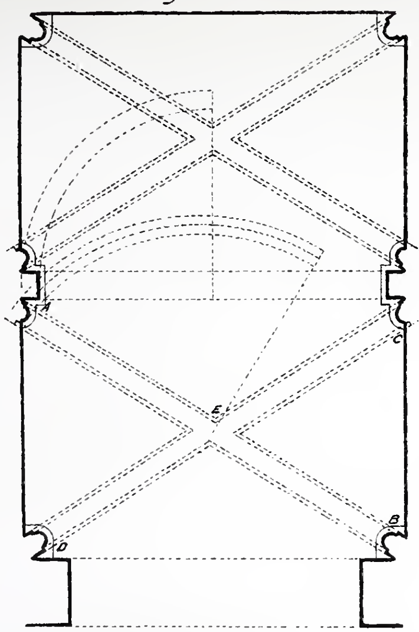


Fig: 1

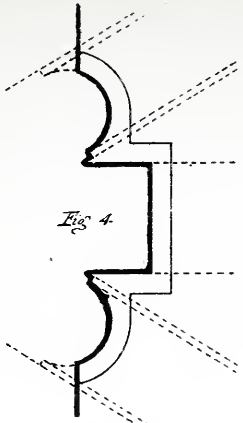


Fig 4.

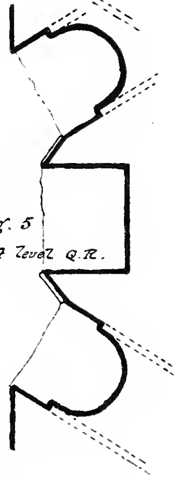


Fig. 5
Plan at level Q.R.

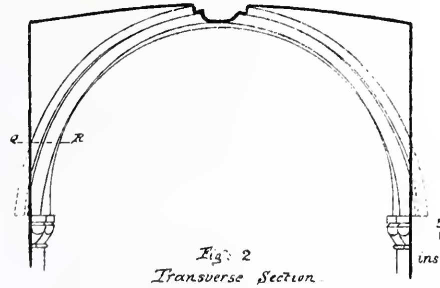


Fig: 2
Transverse Section

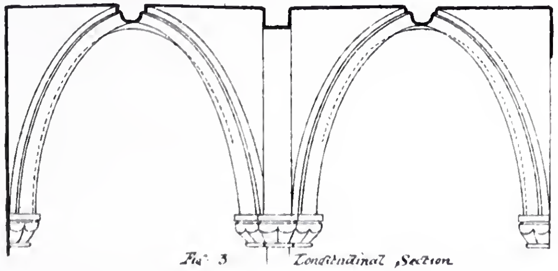


Fig: 3 Longitudinal Section

Scale for Details

S MARY. MINSTER. THANET.

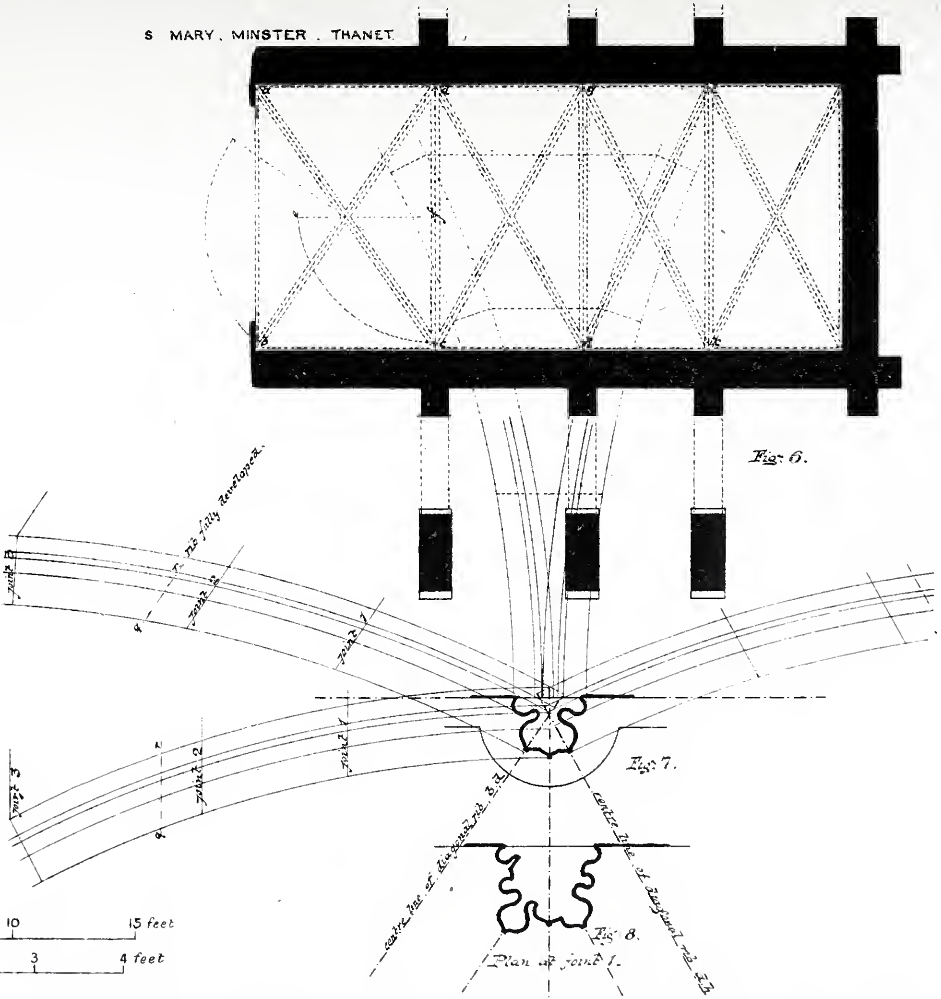

rib fully developed
joint 3
joint 2
joint 1
joint 3
joint 2
joint 1
centre line of diagonal rib 3.3.
centre line of diagonal rib 3.3.

Fig: 6.

Fig: 7.

Fig: 8.
Plan at joint 1.

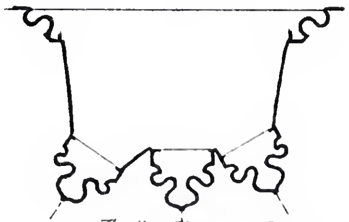


Fig: 9 Plan at joint 3.

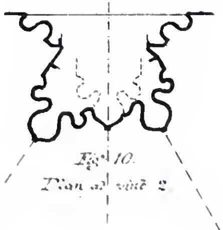


Fig: 10.
Plan at joint 2.

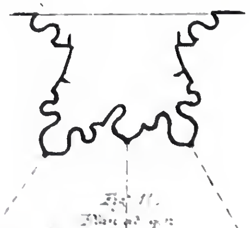


Fig: 11.
Plan at [illegible]

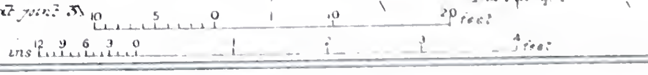


Photo lith^d for the R.I.B.A. by C F Kell London

noticeable in the vault over the chancel of St. Mary Minster, Thanet, a plan of which is given in Plate II. Fig 6. It consists of four bays of quadripartite groining of varying widths, the first of which from the west is wider than the others. The transverse ribs are very obtusely pointed, almost semi-circular, the outline of the *soffit* of one of them is given at *c e d* Fig. 6; the ridge from east to west is level, consequently the rise of the diagonal ribs is given by the line *e f*. Their outline is segmental, *not pointed*, and, consequently, the centre from which each is struck, is at a greater or less distance below the springing line according to the greater or less span of each, *i.e.* according to the greater or less width of the various bays. The various ribs in the spandrel solids, *g*, *h*, *k*, *l*, all mitre very fairly; but in those *c* & *d* owing to the greater span of the ribs *a c*, *b d*, and *their consequent greater obliquity to the vertical* at their springing, they are thrown forward, and become detached from the rest before these last are completely developed, and the awkwardness spoken of ensues. The details on Plate II. shew this, I hope, clearly, but before explaining them I must notice a very important detail of construction, which the principle of making the ribs interpenetrate introduced. This consisted in forming the block of masonry at the springing (to a height such that the ribs by their spreading had completely disentangled themselves from each other, and could each be continued as a separate arch formed of independent voussoirs), with horizontal courses. This block is known by its French name of the *tas de charge*, there being, I believe, no equivalent term in the vernacular. The first two or three courses of the spandrel solid would each be worked out of a single stone only, and the pressures exerted by the various ribs being thus brought together into a single mass of material of comparatively limited area would necessarily combine and produce a single resultant, the action of which could be resisted by judicious buttressing. The genuine arch construction of each rib would therefore begin only when it became entirely disentangled as it were from the other ribs, up to such point, the construction being in fact mere corbelling out. A further advantage of this method is obviously that it reduced the span and consequent horizontal pressure of the arches forming the ribs. To return to the examples given on Plate II. Fig. 7, is a plan of the lower bed of the spandrel solid *d*; the ribs are merely rudimentary, consisting, in fact, of very little more than the front fillet. On the centre line of each rib as base line, the lower part of the elevation of each is shown by the fine lines, and the successive horizontal beds of the courses of the *tas de charge* are shown by the lines 1, 2 and 3. From these elevations the plan of the spandrel solid at the successive joints can easily be obtained; they are shown at Figs. 8, 9 and 10. At the first joint (Fig. 8) we find one side of the diagonal rib *b d* fully developed, while on the other it is still entangled with the transverse rib, which develops more slowly than either of the others. At the second joint the two wall ribs are clear, and half of each of the diagonal ribs; but the rib *b d* is more out of the solid than the rib *d h*. At this level there is a very narrow strip of filling in between the diagonal and wall ribs. At the third joint (Fig. 10) we are at the level at which the transverse rib is completely developed, and the *tas de charge* construction ends, the surface of the stone over the ribs proper being worked off, so as to give beds radiating to their respective centres. The diagonal ribs clear themselves from the solid at some point intermediate between joints two and three, though not both at the same level, the rib *b d* being perfect at the level *q r*, a plan through which is given (fig. 11) showing the rib *d h* to be still engaged with the transverse rib.

The irregular mitreing of the moulded ribs, which was unavoidable when the various ribs were all of different curvatures, as in this example, must however have been felt to be somewhat unsatisfactory and defective, and when vaults of great span and formed of wide bays were attempted, in which for the additional security of the filling in intermediate ribs between the transverse and diagonal, and diagonal and wall ribs were introduced, matters became still more complicated. The solution of the difficulty was found in making each rib a compound instead of a simple curve. By this means each rib, no matter what its span, could be formed with its lower portion of any desired curvature, and thus the simultaneous development of adjacent sides of the various ribs from the spandrel solid could be ensured.

Plate III. Fig. 1, shows the plan of one quarter of a bay or severy of a vault, with one intermediate rib between the transverse and diagonal, and three between the diagonal and wall ribs. The ribs are at equal angular distances apart, so that if we make the sections of all the ribs uniform, and place their front edges or fillets on the quadrant of a circle, as at A, we must make the lower part of all the ribs of the same curvature, which will necessarily cause the simultaneous perfect development of the ribs. Fig. 2 shows possible elevations of most of the ribs. Setting off the lengths $A' h$, $A' f$, &c., of their plans as given between the quadrant at A, and the centre lines D B, D H of the bay; and erecting perpendiculars $h\ H'$, $f\ F'$., &c., at their extremities, the crowns of the various ribs must lie somewhere on these perpendiculars. Suppose we settle first on the diagonal arch, and make it slightly segmental, its centre being at S; the elevation of the soffit of this rib will be the line $A\ P\ D'$. The next thing to determine will be the form of the ridges, and provided we allow ourselves latitude as to the curves of our ribs, this is almost purely at the pleasure of the designer. Say we decide to have the main ridge D B horizontal and the transverse ridge D H sloping down slightly from D to H, as shown by the line $D'\ M$. Then, drawing $D'\ B'$ horizontal, we determine B', the vertex of our transverse rib. We have now to describe an arc which shall pass through B' and touch the arc $A\ P\ D'$, at some point P, the position of P being arbitrary, provided it is not taken too near the springing line; the centre of a curve fulfilling these conditions, is easily found by trial (the radius need vary but little from that of the diagonal rib), and supposing it to be where shown, we have the line $A'\ P\ B$ as the elevation of the soffit of our transverse rib. The intermediate rib A C will finish at C', and its centre might obviously be taken between S and the centre from which $P\ B'$ is struck, but I have not shown it in order to avoid confusion in the figure. For the rib A E we can determine the vertex by making $D'\ e' = D\ E$, dropping a perpendicular from e on to the inclined line D M, and from its point of intersection drawing a horizontal to meet $e\ E'$ in E', and proceeding exactly as before, we find a centre from which an arc may be struck touching A Q D in Q, and passing through E, and we thus get $A'\ Q\ E'$ as the elevation of the soffit of rib A E. The same process may be applied to the remaining ribs.

I have drawn the elevations of two of them: $A'\ RF'$ of rib AF and $A'\ RH'$ of AH. The elevation of $A\ G$ would obviously lie between these two curves, but is omitted to avoid confusion. This, then, is the complete solution of the problem, the data being as supposed. Instead of the conditions proposed, it might be required that all the ribs should consist (so far as their span allows) of the same curve. This simplifies the problem, but it will be observed that the form of the ridges is no longer arbitrary. Suppose the height $d\ D''$ of the diagonal rib is given, then we have to settle on some such curve as $A'\ F''\ D''$, the lower part of which is struck from s' and the upper part from s'', and the elevations of the soffits of the various ribs are given at once by the arcs $A'\ H''$, $A'F''$, $A'\ E''$, &c. In this particular example the wall rib becomes a simple pointed arch struck from centres a little below the springing line.

We might, however, have the ribs irregularly placed, and with their front edges placed anyhow on the abacus. A plan of the angle of such a vault is given in fig. 3, Pl. I. There is one rib between the diagonal and the transverse, and two between the diagonal and wall ribs, and the ribs are arranged so that their front fillets touch the sides of a rectangle as shown. In this case it is the points a, b, c, d, &c. in which the outside lines of the plans of the ribs intersect, on which the solution depends. As before, let us first settle the elevation of the diagonal rib, and suppose $A'\ L\ M\ N$ to represent its lower part, $M\ N$ being the back edge on which the filling in rests. If we project a on to the centre line of the rib in p, transfer the length $A\ p$ to $A'\ P'$, and draw $P'\ R$ perpendicular to the horizontal $A'\ P'$ intersecting $M\ N$ in R, R is obviously the point at which the back edge of the diagonal ribs passing through

Pl. I.

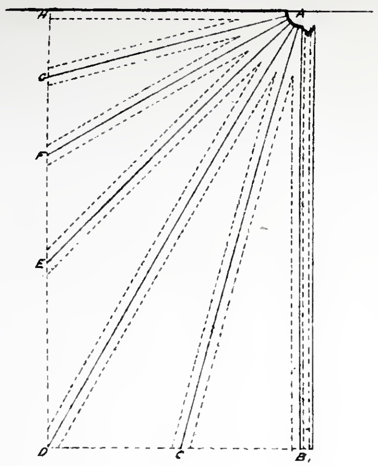


Fig. 1

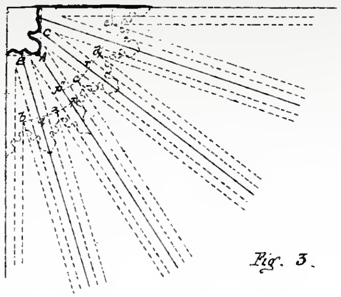


Fig. 3.

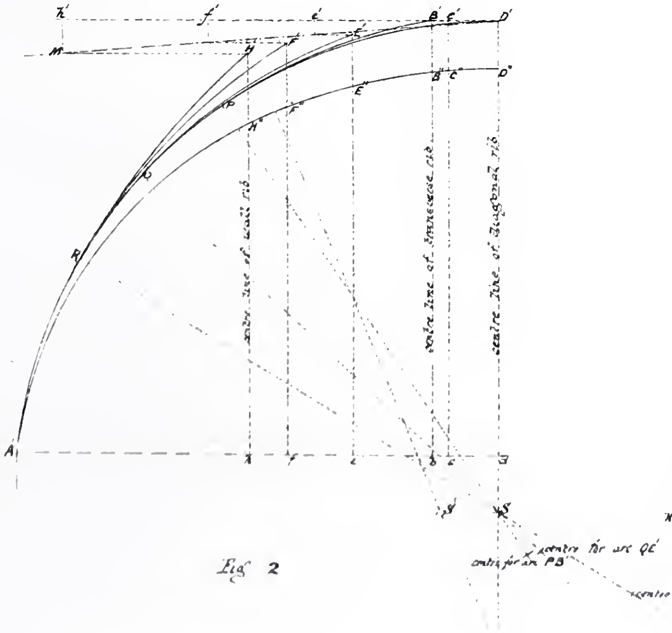


Fig. 2

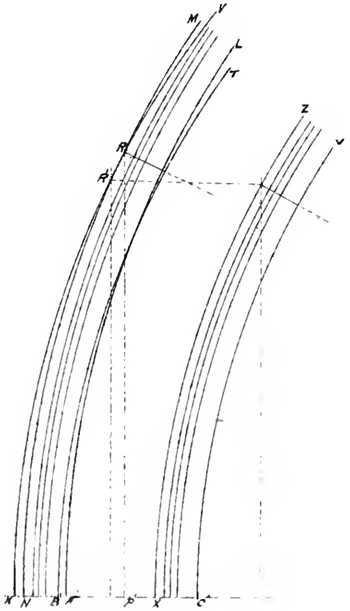


Fig. 4.

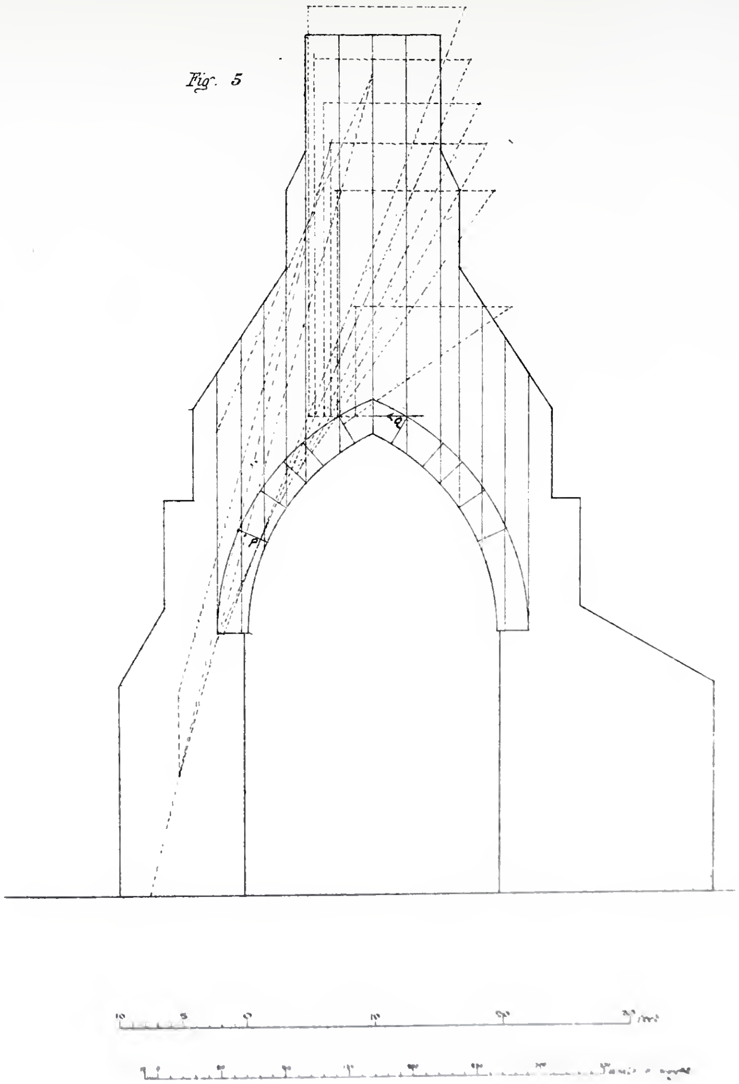


Fig. 5

[illegible] RA

Photo lith. for the R I B A by G F Kell London

a ought to come out of the *tas de charge*, the point at which one side of the diagonal ribs is completely developed. Hence R must also be a point on the back edge of the adjacent rib $B\ q$, and, therefore if we project a on $B\ q$ in q, transfer $B\ q$ to $p'\ B'$ and make $B'\ K = A'\ N$ the depth of the rib, we have another point K through which the back edge of rib $B\ q$ must pass, and hence the curve of the lower part is determined, as $B'\ T\ V\ K$. By using a compound curve the vertex may obviously be made at any desired height, as before explained. Proceeding in an exactly similar manner with the point c, we get R', the point common to the back edges of the diagonal rib and adjacent rib $C\ r$, and we get for the elevation of its lower part as at $C'\ Y\ Z\ X$.

The dotted outlines of the ribs on the plan show the plan at the full development of the ribs, the part between the diagonal and wall ribs being taken at level R' and between diagonal and transverse rib at R.

In vaults where the ribs are numerous and all parts of the same curve (fan vaults), the spandrel solid becomes practically a solid of revolution generated by the motion of a simple or compound curve round a vertical axis. Our own country is their home *par excellence;* on the Continent, architects scarcely went beyond the perfect quadripartite vault, and though our late and elaborate examples are triumphs of stone cutting and technical skill, they exhibit scarcely any new principle, and with the perfecting of the earlier method the difficulties of vaulting may be said to have been overcome. Such vaults, indeed, as those of King's College Chapel, Cambridge, and Henry Seventh's Chapel, Westminster, must be considered to some extent debased and as exhibiting false construction, inasmuch as in them the ribs are not veritable independent arches forming a permanent centering, on which a thin shell forming the filling in is laid, but the vault is really of solid masonry, the apparent rib and panel work being mere ornamental sinkings in the solid stones of which it is composed. Gorgeous though they are, still I think they are really of minor importance, and the interest of the subject is to my mind to a great extent exhausted when the problem which the early Romanesque builders set themselves to work out was once fairly and fully solved.

I will conclude these hasty notes with the following passage from Street's charming book, "Brick and Marble in the Middle Ages;" it is, I think, worthy to be constantly in the remembrance of every architect:—

"The real beauty of these interiors" (of the churches in Venice) "is owing, I believe, more to the noble simplicity and purity of the quadripartite groining which arches them in, and which, even where other features would seem to tell of debasement and absence of feeling, invariably recalls us to a proper recollection of the infinite value of simplicity in this important feature.... It is not difficult to prove that this must be the case, for I take it for granted that we all feel that ornament for its own sake is valueless, and equally that doing in a troublesome and therefore costly way that which may as well be done in a simpler manner, is unpleasant and distasteful as an exhibition of the wasteful expenditure of human skill and energy; and therefore, as simple quadripartite groining with diagonal and transverse ribs and none intermediate, is quite sufficient for construction, and is in no degree whatever strengthened by the multiplication and ramification of perplexing ribs, common even in our early work, and in later days sinking into the effete and senseless luxury of fan tracery and its contemporary modes of vaulting—that, therefore, the simplest is the only true and thoroughly defensible system of roofing in stone."

Mr. Phené Spiers.—It is especially difficult to make any remarks upon the paper we have just listened to with so much profit, because a great portion of it has been omitted, and we are not in possession of the reasons which led in many cases to the points which Mr. Eagles has illustrated upon the board. Although Monsieur Viollet-le-Duc was, I think, the first to point out that the construction of the Roman vaults was not simply of *béton* or stone, he was preceded by others. It had been found out by French architects before that, and in Cameron's work on Roman Vaults ; and in Blouet's work on the Baths of Caracalla, it was shown that the vaulting in the Baths of Caracalla was composed of ribs or lines, with *béton* between. These ribs were built on centres, with the boards placed in between the vaulting in respect of the vaults. It had also been previously pointed out how vaulting had been introduced in conjunction with trabeated construction in the vaults of the Pantheon at Rome. The size of the Baths of Caracalla and Diocletian was such, that in the adoption of vaulting supporting ribs were absolutely essential, but the Romans preferred to hide these supporting ribs, and never show them in any way. Vast flat surfaces seem to have been sought after, and excavations at the Baths of Caracalla have shown that the greater portion of the vaults were covered with mosaics, spread evenly over the surface, the greater portion consisting of octagons or circles, not simply constructive, but decorative. The point which Mr. Eagles has raised, as regards the difficulty of getting transverse ribs free from the web before the diagonal ribs is, I think, got over by setting back the diagonal rib on the abaci. [Explained on the black board.] The height at which the ribs separate themselves could easily be calculated. I am not sure whether this is not the way in which the problem was always solved, and the employment of the double curvature was due, I think, to another cause. I am not aware of any example of the double curvature until we come to those roofs, which are known as "fan vaulting," and in these the object to be effected would be economy of centres, because they would have a certain number of ribs all starting from the same point, and you may use the same centres for each of them. One of the reasons why in France they never arrived at fan vaulting was, that they had so few ribs that there was not much expense in making transverse and diagonal centering. In England, in consequence of our different system of webbing, first we had introduced the ridge rib ; then we had other ribs introduced, and the consequence was, that at the end of the thirteenth century we find in England a variety of ribs, which scarcely existed in France in the fifteenth century. This circumstance was due to the fact that in France the vaults were almost always domical, while in England, on the other hand, they were level. In France at the present day, vaults are mostly constructed on the domical principle ; and although the French mind would be inclined to avail themselves of the elaborate work which could be attained by the rib system, yet they always employed the simple diagonal rib rather than resort to a more involved and complicated system of stereotomy. There are one or two other vaults in France, which, I think, are worthy of notice, but it is difficult to say how far they come within the proper principles of vaulting. The best examples are found in the Church of St. Pierre, at Caen, at Ferte Bernard, at Senlis, and in other churches in Picardy. In these vaults the ribs are elaborately carved, and the web consists in many cases of flat slabs of stone, the interval between the soffit of these slabs, and the upper surface of the rib being filled with tracery and other decorative forms so that the upper surface of the web is level. As far as the ribs are concerned the principle is similar to that found in all vaulting, and its result is extremely beautiful ; and I think it is really based on a sounder principle in some cases than the English fan vault. There are one or two instances of fan vaulting in France—Caudebec, for example. As regards the cutting of rib and web from one stone, in the fan vaulting at Gloucester Cathedral, the ribs and the web are entirely separate. In the later works, as in the Divinity Schools at Oxford, and, I think, in Westminster Abbey, they found it more convenient, and very easy in these elaborate ribs, to get both rib and web out of the same stone, so that what they really came to without knowing it was simply the vault construction of the Romans, the ribs being merely superficial bands cut out of the solid stone. I think the paper we have just heard read by Mr. Eagles, is one of extreme value, not only to members of the Institute, but to all architectural students. Mr. Eagles has referred to the paper read by Professor

Willis, in 1842, which has been, I think, of more use to students than any paper read here. Professor Willis's paper on vaulting has been followed up in one or two cases by others; and I think that although Mr. Eagles has not travelled over so much ground as Sir Gilbert Scott, who in his lectures at the Academy, elaborated one or two very important points, this essay cannot fail to be of great use to the profession. I have, therefore, great pleasure in proposing a cordial vote of thanks to him for his very valuable contribution to our "Transactions."

Mr. DAWSON.—I have very great pleasure in seconding the motion for a vote of thanks to Mr. Eagles. I have listened to the paper with peculiar pleasure, and I am sure that I shall derive increased pleasure and instruction from following out the mathematical explanations and reasons upon which the author's statements are based, and which, although not read, are I understand to be printed* I think the instances he mentioned of the lines of compound curvature in vaulting ribs were particularly interesting, and show that many of the difficulties which we do meet with are capable of being easily overcome. With reference to the use of level stones on the top of perforated ribs of vaulted ceilings, I have an impression there is an instance in Bristol Cathedral, and I should like to ask Mr. Phené Spiers if this is so. [Mr. Phené Spiers.] I cannot say, but I think it is very likely. [Mr. Dawson.] I think there is, and I quite concur in thinking them sometimes very beautiful, although they are not so pure a style of vaulting on the earlier examples.

Mr. PHENÉ SPIERS.—One word more. Mr. Eagles says that vaulting, especially in its first development, was the first germ of the clustered pier. I think, however, that the clustered pier was common before that, and was necessitated by the different orders of arches. I think the vaulting pier was long subsequent.

MR. THOMAS MORRIS Associate:—I desire to say a word, sir, in admiration of the paper so ably presented by Mr. Eagles. The subject is a magnificent one, but exceedingly difficult. I hope we may regard this essay as simply a first stage in its treatment, and that Mr. Eagles will continue the investigation with the spirit in which he has commenced. I should have been glad if he had gone rather more deeply into the question of Roman vaulting, and developed the tendency evinced in some works to rib constuction, as well as the mode in which the centering was applied. Roman bridge construction had the same tendency, and its examination would help to a knowledge of the technical mode of operation. When we come to English work, I am hardly aware that the Normans ever really mastered the subject. I do not know that there is any standing example of an English Cathedral with a groined nave, of twelfth century date. Examples of the vaulting shaft spoken of are found in Norman work, but I am not at all aware that the contemporary groining of the Norman nave of any English Cathedral exists. It is a question, of course, whether the builders really failed in that department, or whether it was their intention simply to construct a gable or rib of brick or stone—at that time they used stone—and satisfy themselves by throwing out over the vaulting shafts a series of gables with soffits, perhaps in two parts—a sort of double moulding, in fact, and so roof the naves of their churches in the same way as the halls of the Welsh castles were covered, that is with stone gables and not with vaults at all. The subject has many points of interest, but this is perhaps, one of the earliest and most interesting. Both Mr. Eagles and the Institute are to be congratulated on the merit of this essay, and when it is recollected that Mr. Godwin was an early prize essayist, it would appear that from Mr. Godwin's time to this, very few essays have been presented worthy of commemoration at all. The present is, however, a subject that requires exemplification. It is one, indeed, on which any amount of illustration might be expended, and I hope that Mr. Eagles will at some future time, give us a supplementary paper so accompanied. The production of sessional papers is one of the most important objects which the Institute can aim at, and one way in which the means at command might be well directed, would, I should say, be in the encouragement of really successful and practical essays. Whether the inducements to writers are insufficient, or any cause of discouragement exists, I do not presume to inquire, but the point may be not undeserving of consideration by the Council of the Institute. Mr. Eagles at any rate, has given an admirable example and I am gratified by the feeling that his paper, though the last of the session, will be one of the most valuable in our "Transactions."

---

* See the Appendix to this Essay.

The CHAIRMAN.—I have much pleasure in putting the motion to the meeting, and in personally thanking Mr. Eagles for his excellent paper, and I think if he will pursue the subject a little further great good will result. I can recollect when, with Sir Charles Barry in my early days, having a considerable amount of vaulting to design, we had actually to set out every stone geometrically for the large number of vaults we constructed. I have since executed many examples of Gothic vaults in my own practice, and I have also executed Norman vaults in churches. I quite concur with the last speaker (Mr. Morris) in thinking that if we could induce some of our members to give us such valuable papers on construction as we have heard to-night, our meetings would be far more instructive and profitable. The constructive element has, I think, been too much neglected of late years, and I would therefore earnestly ask some of our members to furnish us with papers for next session, particularly on matters of construction. Whatever may be said about the beauties of architecture as an art, let it not be forgotten that the very elements of our art are founded upon constructive principles. In presenting to Mr. Eagles your hearty vote of thanks, I most cordially acknowledge the instruction which I have received from his paper.

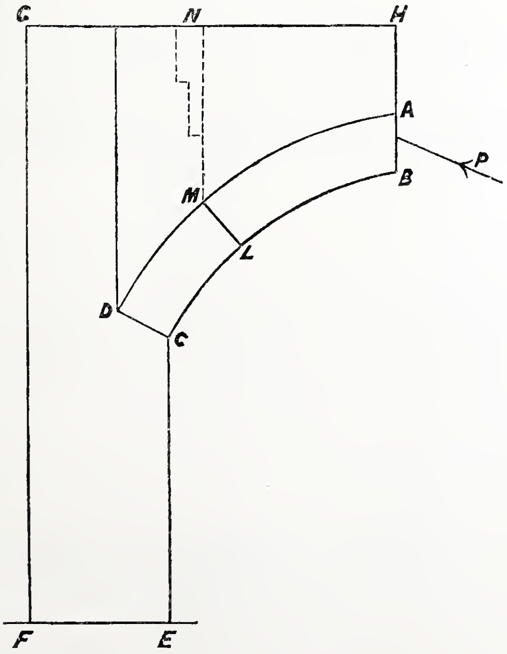
Mr. EAGLES.—I thank you very much for your kindness. With regard to the objection which has been made to my theory of the compound curvature of ribs, if we use simple curves, and arrange them so as to mitre properly, it is quite possible for the diagonal ribs (being of greater span) to be inclined at so great an angle (explained on black board), that the nosing of the rib would really fall inside the wall line, before it reached the supporting abacus, and although it is very difficult to measure the accurate curvature of the ribs of any vault, not only on account of the difficulty of getting at them, but also because we can hardly ever be sure that no settlement and consequent deformation of the ribs has taken place—yet in many cases it is certain that the curves are compound. From a careful examination of the vaulting in Beverley Minster, I have convinced myself that compound curves are there used in the ribs; and I noticed recently in Worcester Cathedral that some of the ribs have a distinct twist in them. So far as my own acquaintance with examples goes, either the various ribs composing a spandrel solid do not mitre fairly, or one or more of them are made up of compound curves. With reference to what I have said as to the origin of the clustered pier, there can be I think no doubt that the necessities of vaulting led to the introduction of detached shafts to support one or more pairs of the ribs, and it seems at least reasonable to suppose that this constructional necessity was afterwards developed into the central pier surrounded by satellite shafts. We often find orders in arch moldings carried on a square octagonal or circular abacus, and there seems no real difficulty in always so arranging them, but it is a far more complicated, we may almost call it an insoluble problem, to seat a bundle of wide ribs satisfactorily on an abacus of regular outline. My earnest apologies are due for the absence of diagrams. The essay itself was illustrated, but I had no copies of the sketches which accompanied it, and the originals did not come into my hands again until quite recently, since when, owing to a heavy pressure of other engagements, I have been quite unable to prepare such diagrams as I should have desired.

The Discussion having been brought to a close, a vote of thanks was unanimously passed to Mr. Eagles, and the meeting adjourned.

APPENDIX TO THE ESSAY ON VAULTING.

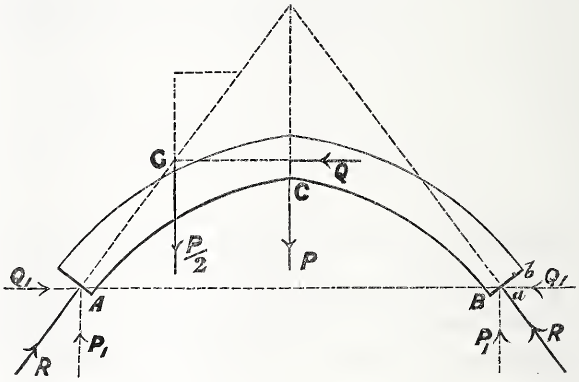
THE theory of vault construction depends entirely on the theory of the arch, therein differing essentially, I think, from that of the dome. For this reason the foregoing Essay is confined entirely to vaulting proper, and the few following pages are devoted almost entirely to the consideration of arches proper; the theory of which, if thoroughly appreciated, can be easily modified and applied to a vault of any form.

Some years ago Mr. E. W. Tarn, in some papers contributed to "the Builder," examined the question, but owing to the excessive complication of the trigonometrical formulæ he employs, his method can scarcely be said to be practically applicable. In the explanations which follow, I have carefully avoided all abstruse mathematics, and have dispensed with trigonometry. A knowledge of elementary mechanics (composition and resolution of forces and principle of moments) is alone necessary for their perusal.



If we have a half arch ABCD of any form resting on an abutment DEFG, and with a surcharge such as GH, there is obviously a lack of stability in the structure; the weight of the projecting portion would tend to break off part of itself, and the arch might separate along a joint such as LM, and an irregular crack would run up through the surcharge, the portion HBLMN falling. To simplify matters, suppose the separation between the two parts of the surcharge to take place entirely in one plane, and that plane to be vertical: the line MN is then vertical. The upper portion would fall, either by turning round the edge L, or by sliding along the joint LM. The falling might obviously be prevented by the application of a sufficient force P to the joint AB, and the inference is, that in a complete arch one half exerts some such force as P against the other. We know as yet nothing as to the direction or point of application of P, beyond the fact that it is somewhere within the joint AB;

and it may be said that the determination of its actual point of application constitutes the chief difficulty of the problem. The principle followed below was first enunciated by Moseley, and published in the Philosophical Magazine for October, 1833. It was called by him the "principle of least resistance," and an application of it to the theory of arches has been carefully made and elaborately worked out by Dr. Hermann Scheffler, of the Public Works Department of the Duchy of Brunswick. It may be explained thus:—Suppose we have an arch ABC, symmetrical about its centre line, and supported on immovable abutments at the joints A and B. These abutments exert reactions which might be replaced by forces acting at some definite point of such joints, and by symmetry they will be equal, and will act at points in the same horizontal line, wherever such line may be with respect to the joints A and B. Let these reactions be R and R, and the principle requires that R shall be the smallest force possible consistent with equilibrium.



Nature is intensely conservative of her energy; she will exert so much and no more than is necessary for a certain effect, and hence if by acting at a point *a* the arch can be kept in equilibrium by a smaller force (R) than would be required at *b*; *a* is the point through which the resultant reaction will pass. Now, resolve the two forces R into their vertical and horizontal components P and Q_1; we have

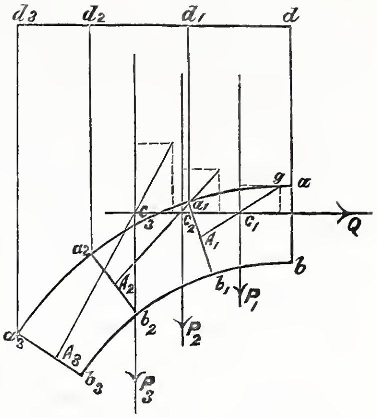
$$P_1 + P_1 = P, \text{ the weight of the whole arch, or } P_1 = \frac{P}{2}.$$

Consider the equilibrium of one half only of the arch: we have its weight $\frac{P}{2}$ acting vertically, which will balance the vertical component P_1, of the reaction R; and we must therefore have a horizontal force Q acting at some point of the centre joint, the direction of which must pass through G the intersection of $\frac{P}{2}$ with R.

Since R is to be a minimum and its vertical component is constant ($= \frac{P}{2}$), we must have its horizontal component Q_1, also a minimum, and consequently also the force Q, acting horizontally on the top joint. Let *h* be the horizontal distance between the vertical through G, and the point of application of the resultant force R, *q* the vertical height of line of action of Q above the same point: then, taking moments about this point, we have—

$$Q. q. = \frac{P}{2} h \text{ or } Q = \frac{P}{2} \frac{h}{q}.$$

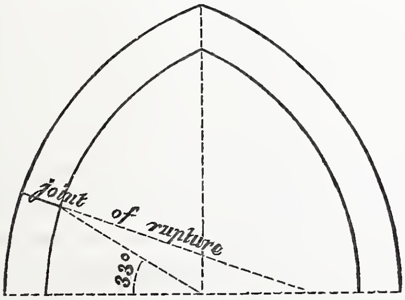
hence Q is a minimum if we make *h* as small and *q* as large as possible; *i.e.*, the point of application of R must be as near as possible to the intrados, and of Q as near as possible to the extrados as is consistent with equilibrium.



Let ab, a_1b_{11}, a_2b , a_3b_3, be the joints of any arch, with a surcharge to dd_3. P_1 P_2 P_3 the vertical directions of the weights of the portions bb_1 a_1 d_1d; bb_2 a_2 d_2d; bb_3 a_3 d_3d. Q the horizontal pressure at the crown cutting the directions of P_1 P_2 P_3 in C_1 C_2 C_3; the portion of the arch supported on joint a_1 b_1 may be taken to be the part bb_1 a_1 d_1 d; the weight of which (P_1) acts through C_1, and therefore, if at C_1 we complete the parallelogram C_1g, with sides proportional to Q and P_1, its diagonal being produced to meet the joint a_1 b_1 in A_1, gives the point on this joint through which the resultant action of P_1 and Q passes. Proceeding in exactly the same way with the mass bb_2 a_2 d_2 d supported on the joint a_2 b_2 we get A_2, through which the resultant action of P_2 and Q passes, and similarly for A_3, the corresponding point for the joint a_3 b_3.

If we take a sufficient number of joints in any arch, we thus get a series of points, the lines joining which will form part of a polygon of a great number of sides coinciding very nearly with a curve drawn through the points. This curve is the "*line of pressures*" in the arch ring, and the condition of stability of any arch is that this "*line of pressures*" shall always be well *within* the arch ring, *i.e.*, shall never approach within a limiting distance of either the intrados or extrados. Rankine advises that it should always lie within the middle third of the depth of the ring; but this is in excess of the actual requirements, and within the middle half would give abundant stability.

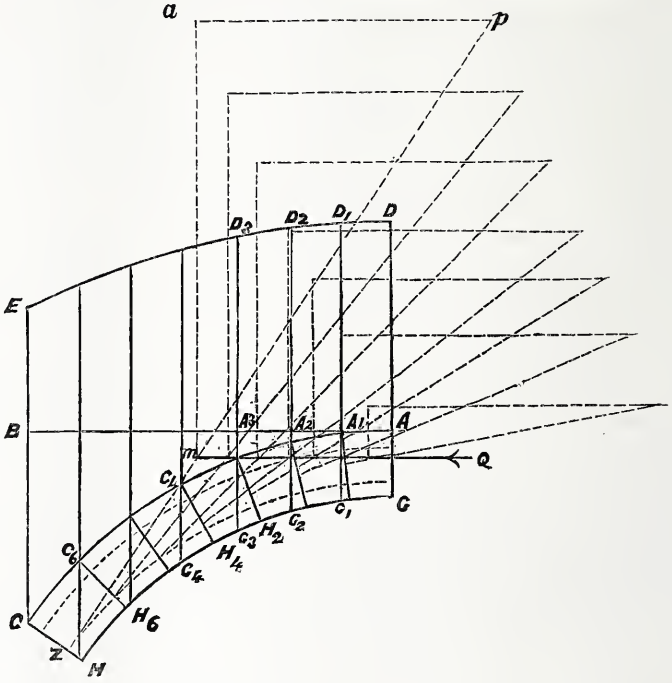
The following practical method of proceeding in ascertaining if any proposed arch possesses the necessary stability will further explain the theory. A curve of pressures is determined, if we know one point in it, and the magnitude and direction of the pressure at that point; it is also determined, if we know the exact position of two points on the curve, as explained below. The real curve of pressures approaches the extrados at the upper part of the arch, and the intrados at the lower, and if the arch is unstable, it would generally rupture at this lower point; the line of pressures in fact approaching too near to the intrados, or even falling altogether within the soffit of the arch. Hence at the joint of rupture the line of pressures is at the *limiting* distance from the intrados, and we make use of this property in what follows.



The position of the joint of rupture varies with the form of the arch. In semi-circular arches it is the joint inclined at from 30° to 35° to the springing line, and in pointed arches it may be taken approximately about where a line drawn through the point where the perpendicular from the crown meets the springing line, and inclined from 30° to 35° to the springing line, cuts the intrados. In segmental arches it is almost always at the springing.

The most expeditious way of proceeding is to *assume*, a little arbitrarily, two points on the curve of pressures, viz., the points in which it may be presumed to intersect the joint of rupture, and the joint at the vertex. We can then find the horizontal force acting at the vertex under the assumed conditions, and can verify if those conditions actually hold; if they do not, we must modify our hypotheses, and it is always easy to make a new construction in which most of the elements employed in the first come in serviceably.

The following is the whole process :—



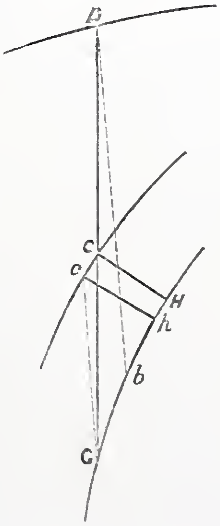
Let A C G H represent any arch with surcharge E D, the whole being composed of the same materials. Suppose we are dealing with a slice 1 foot thick measured perpendicularly to the paper. Taking as our unit of weight, the weight of a cube foot of the masonry of which it is composed, the area in square feet of any vertical surface will represent the weight of the corresponding portion of the masonry. Divide up A B into any convenient number of parts, not necessarily equal, though they are taken so in the present case, and through the points of division draw vertical lines from the intrados to the top of the surcharge. Calculate successively the areas of the figures D G G_1 D_1, D_1 G_1 G_2 D_2, &c., considering each as a rectangle of the breadth and mean height of the corresponding block. We may assume without appreciable error that the centre of gravity of each figure lies on the vertical drawn midway between its sides, *e.g.*, the centre of gravity of D_2 G G D_3 lies on the vertical dividing A_2 A_3 into two equal parts; and we also assume that the mass D D_3 G_3 G represents the weight resting on the joint C_3 H_3, and so for the other joints. This is tantamount to neglecting the triangle H_3 G_3 C_3, an error generally very small, though sometimes a correction for this may be necessary, to which I will return.

We are now ready to prepare a table such as the one on the next page. Call the block D$G_1$$D_1$, adjacent to the centre line of the arch, No. 1—the next No. 2, and so on, and put their numbers successively in the first column (1). Column (2) is for the widths of the successive blocks, (3) for their mean heights, and (4) for their areas calculated from (2) and (3). Column (5) is for the horizontal distance of the centre of gravity of each block from the centre line of the arch. It is of course the sum of the widths of the previous blocks + half the width of the block under consideration; (6) is for the product of (5) and (4), which represents the moment of each block about the centre line, (8) is for the sum of the areas of the successive blocks as shown in (7); and (9) is for the sum of corresponding successive moments; (10) is the result of dividing (9) by (8), and by the principle of moments obviously gives the distance of the centres of gravity of the successive blocks D G G_2 D_2, D G G_3 D_3, D G G_4 D_4, &c. from the centre line, *i.e.*, the vertical lines in which the weights of these successive compound blocks act are determined

The sums of (4) and (6) ought to be identical respectively with the last number in (8) and (9).

Elementary Weights.						Partial Summation.			
Nos.	Width.	Height.	Area.	Arm of Lever.	Moment.	Nos.	Area.	Moment.	Arm of Lever.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	′ ″	′ ″	′ ″	′ ″			′ ″		′ ″
1	2.0	10.6	21.0	1.0	21.0	1	21.0	21.0	1.0
2	2.0	10.8	21.4	3.0	64.0	1 + 2	42.4	85.0	2.0
3	2.0	11.0	22.0	5.0	110.0	1 + 2 +3	64.4	195.0	3.0
4	2.0	11.8	23.4	7.0	163.4	1 + ... + 4	87.8	358.4	4.1
5	2.0	12.6	25.0	9.0	225.0	1 + ... + 5	112.8	583.4	5.2
6	2.0	13.6	27.0	11.0	297.0	1 + ... + 6	139.8	880.4	6.4
7	2.0	13.6	27.0	13.0	351.0	1 + ... + 7	166.8	1231.4	7.5
	14.0		166.8		1231.4				

Now our curve of pressure is always to fall within the lines dotted on the arch ring, and since the joint of rupture in this example would be at springing we can take the point Z as the point through which the resultant action of the whole half arch passes, and assume the horizontal force Q at crown to act along line Q*m*. From the table we see that the resultant weight of D G H C E acts at 7 ft. 5 in. from the crown, and we draw the vertical *m a* at this distance. The direction of the resultant force on joint C H must pass through *m*—hence Z *m* is its direction, draw Z *m* and produce it to *p*. Make *m a* proportional to the weight of D G H C E (the weight of 167 cubic ft. of masonry), draw *a p* horizontal and *a p* represents the horizontal force Q at crown (weight of 115 cubic feet), while *m p* represents the total resultant force acting on joint C H. The point of application and the direction of the resultant pressure on any joint (C_4 H_4 for instance) is found now at once by simply compounding the weight of the mass D G G_4 D_4 (88 cubic ft.) acting at a known distance (4′.1″) from D G with the horizontal force Q acting along Q *m*. Producing the diagonal of the parallelogram of forces to cut the joint gives us the required point. Similiarly for all the other joints.



In the given example it will be seen that the curve of pressures does not reach the upper dotted line in the arch ring; this shows that we have assumed Q to be acting too low and that it should be taken on the dotted line.

Sometimes near the springing of a pointed arch the triangle H G C above referred to, becomes too large to be neglected—in that case we can correct the joint thus: let D C G be the division between two of the blocks into which we divide arch and surcharge. C H the corresponding joint as usually taken. Bisect G H in *b*, draw G *c* parallel to D *b*, and take *c h* as the joint instead of C H.

In the example shewn in Fig. 5, Pl. I. this correction has been made. This drawing shews the chancel arch with bell gable, &c., in All Saint's Church, Windsor, the table comes out as follows :—

Elementary Weights.						Partial Summation.			
Nos.	Width.	Height.	Area.	Arm of Lever.	Moment.	Nos.	Area.	Moment.	Arm of Lever.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8	(9)	(10)
	′ ″	′ ″	′ ″	′ ″			′ ″		′ ″
1	2.8	31.8	84.6	1.4	112.8	1	84.6	112.8	1.4
2	2.8	33.6	89.4	4.0	357.4	1 + 2	173.10	470.0	2.9
3	1.6	25.3	37.11	6.1	230.8	1 + 2 + 3	211.9	700.8	3.4
4	1.8	18.9	31.3	7.8	239.7	1 + ... + 4	243.0	940.3	3.10
5	1.8	20.6	34.2	9.4	318.11	1 + ... + 5	277.2	1259.2	4.6
6	1.11	21.6	41.2	11.2	459.8	1 + ... + 6	318.4	1718.10	5.0
			318.4		1718.10				

The half arch is divided up into six strips of varying width as shewn. P is assumed on the joint of rupture, and Q is taken at the height shewn. The value of Q is the weight of 122 cubic feet of stock brickwork. The curve of pressures would be at the limiting distance from the extrados at about the first joint from the vertex. I have traced the line of pressures down to the ground level by compounding the weight of the abutment with the pressure on the joint of rupture. The trace shews this line of pressures to be dangerously near the exterior edge of the foot of the pier (it is generally kept one-third of the thickness of the pier within it) ; and I think a proof that signs of fracture at one time appeared is, that since the completion of the church, the two piers have been made to correspond, an additional portion having been built on to that on the north side. The drawing shews the arch as it was originally built, and as it stood for some time.

If the surcharge be of different materials, part light and part heavy for instance, we may suppose an equivalant mass of the heavy substituted for the light, and deal with the new form thus obtained for the outline of the surcharge. Applying this to vaulting, we may suppose any rib to be loaded directly by a surcharge equivalent to the quantity of the shell of the vault borne by such rib, which quantity would be obtained from the plan. An approximation to the actual load would be quite sufficient for all practical purposes, and by this means the stability of any vault may be tested by an immediate application of the foregoing principles.

Royal Institute of British Architects.

MEMOIRS OF DECEASED MEMBERS.

(Published in accordance with a suggestion made by the President, Sir Gilbert Scott, R.A., *in his opening address for the Session* 1873-4.)

SIR WILLIAM TITE (Past-President).

Sir William Tite, F.R.S., M.P. for Bath and President of this Institute during several years of office, was the son of a wealthy London merchant, and was born towards the close of the last century in the parish of St. Bartholomew the Great in the City. He received the rudiments of his education at a private school, but seems to have been destined from an early age for the profession in which he achieved such success, and before his fifteenth year was articled to Mr. David Laing, an architect in considerable practice, who at that time was preparing designs for the new Custom House in Thames Street. The erection of this important building afforded an excellent opportunity to the youthful pupil of acquiring a practical knowledge of his art, but it is probable that his studies extended over a wider range, seeing that his skill as a designer was a few years later put in requisition over work of a different character and widely removed in style from the taste of the day. The Church of St. Dunstan in the East, (with the exception of its tower and spire, which had been re-built by Wren) had fallen into decay, and Mr. Laing, then surveyor to the parish, was commissioned to restore it. His imperfect acquaintance with Gothic detail, would have made this a difficult if not an impossible task, but for the assistance of young Tite, who prepared the necessary drawings and superintended the work.* It would be obviously unfair to compare this "restoration" with those which have been accomplished by the skill and enlightened by the researches of later days; but considering that it was undertaken about fifty years ago, it reflects no small credit on its author. The same may be said of the Scotch Church, in Regent Square, built for the Rev. E. Irving about 1827, and designed by Mr. Tite when he was in practice on his own account. To this work Sir William not unfrequently referred with something like pride in later life, averring that he had designed in Gothic, when few of his profession knew anything about it. Meanwhile he had cultivated his mind and improved his taste by foreign travel, and after the usual course of study abroad, he returned to follow his profession in good earnest. Among his early works was the Dissenters' Grammar School at Hendon, which led to many commissions both of a public and private nature. The great success of his professional life however, and the one which speedily brought him fame and fortune, was his appointment as Architect to the new Royal Exchange, which was completed from his designs in 1844. In the open competition that had preceded this selection, Sir William had been an unsuccessful competitor, and this fact will account for some dissatisfaction which prevailed at the time and is still remembered concerning the decision of the Gresham committee. It would be undesirable to discuss in these pages the real merits of the case; it will suffice to state, that for reasons which were no doubt explained at the time, none of the premiated designs were considered suitable for the practical requirements of the building. The consequence was, that the terms of the original and open competition were, whether rightly or wrongly, ignored; that the endeavour to organize a limited competition so far failed, that Mr. Tite found himself pitted against a single rival, and that finally the committee selected his design. The building was erected at a cost of about £150,000, and was opened in person by Her Majesty Queen Victoria. During the excavations which were required for the foundations, many relics of old London were discovered; these, together with some interesting particulars respecting the building of the Old Exchange, formed the subject of a Paper which Mr. Tite read before a Meeting of this Institute in 1845, the first of a long series of Essays with which our Transactions have been enriched by the same contributor.* Next to the Royal Exchange, the London and Westminster Bank in Lothbury, is perhaps the best known of Sir William's strictly professional works, and in the design of this building he had the advantage of being associated as joint architect with a gentleman of high artistic repute and acknowledged ability, the late Professor Cockerell, R.A. Sir William was architect to more than one Railway Company, and probably had in many a large vested interest. At one extremity of the South Western Line he designed the first Vauxhall Terminus, and at the other the Terminus at Southampton. The Blackwall and Gravesend Stations, besides many others in North Britain were also built by him. Indeed his labours in this department of professional work extended to the Continent, and may be noted here and there on the line between Paris and Rouen and between Rouen and Havre. The large Railway Station at Rouen, with its roof spanning nearly ninety feet, is an instance of his structural skill. In 1859 he designed (in conjunction with his assistant, the late Mr. Trotman) the Church of St. James at Gerrard's Cross, Bucks, a memorial raised by two sisters as a monument to their brother, Major-General Reid, M.P. The building is of a quasi Romanesque character, planned in the form of a Latin cross, and surmounted by an octagonal dome. The walls are chiefly of brick, arranged in patterns of red and yellow colour on a white ground. A campanile rises to a height of about 80 feet at one corner of the building, the style of which may be supposed to have been suggested by a study of Pisan architecture.†

---

* A full and illustrated description of this Church, as well as of the new Custom House buildings, was published by Mr. Laing in 1818. The volume is in the Institute library.

On the death of his father, Mr. Tite had succeeded to a handsome competence, which might have kept a less ambitious man in ignoble ease. But though this inheritance raised him beyond the necessity of depending on his profession for a livelihood, it did not prevent him from following it with unflagging zeal. A quarter of a century ago the number of railway works which were carried on in this country was enormous, and Mr. Tite became largely employed as a surveyor in the valuation and purchase of property. So closely was he occupied by this business, and so heavily were his energies taxed in the time, that he paid the penalty of over-exertion by a severe illness, to which he nearly succumbed in 1851. He reaped, however, substantial benefit from his toil, and it was his boast in after years that he had not only inherited one fortune and married another, but made a third for himself.

---

* "Proceedings taken in building the Royal Exchange, by Sir T. Gresham, and that built in 1866, with some account of the Antiquities discovered in preparing for the foundations of the present building," December 15th, 1845. "Recollections of a Course of Lectures on Architecture, delivered at the Royal Academy by Sir J. Soane, 1817," November 30th, 1847, and April 17th, 1848. A "Letter from Rome," May 17th, 1852. "Remarks on the present condition and future of Architecture in England," November 5th and 19th, 1855. "Recent discoveries of the remains of the Mausoleum at Halicarnassus," November 1st, 1858. "Progress of Architecture in Europe since the Establishment of the Royal Institute of British Architects," November 7th, 1859. "Address delivered at the First Meeting of the Royal Institute of British Architects in the New Rooms, Conduit Street," November 7th, 1859, 8vo., 1860. "Stone Preservative Processes," January 28th, February 4th and 11th, 1861. "Some information relating to the late Mr. Elmes, Architect of St. George's Hall, Liverpool," November 30th, 1863. "On the Paris Street Improvements and their Cost," December 14th, 1863. Four Opening Presidential Addresses (November 4th, 1861; November 3rd, 1862; November 2nd, 1868; and November 1st, 1869).

† A full description and view of this Church will be found in the Builder for 1873, pp. 558 and 616.

In 1855, after having unsuccessfully contested Barnstaple, Mr. Tite was returned member of Parliament for Bath, and continued to represent that city up to the time of his death. His duties in the House of Commons, and his official connection with the many important companies of which he was chairman or director, naturally estranged him from at least the artistic side of his professional pursuits, though it did not prevent him from wielding his pen occasionally as a *dilettante* and amateur. As early as 1835 he had been elected a Fellow of the Royal Society, and in 1839 of the Society of Antiquaries, to whose "Archæologia" he was a frequent contributor. His election as President of the Camden Society is an evidence of the esteem in which he was held as an antiquary and man of letters. He amassed during his life a large and valuable collection of books, especially of the early and rare editions of Shakespeare, and an interesting series of illuminated MSS. The contents of his library, which were sold after his death, realized nearly £20,000. In Parliament, though Sir William spoke but seldom, and as a rule only on those subjects concerning which his professional or public position gave weight to his opinion, he was, as may be supposed, an active member of committees, among which may be mentioned, the one appointed to report on the subject of the Bank Charter. In 1874 he introduced and was mainly instrumental in passing the Metropolitan Local Management Act, and it was through his influence that the important duty of examining candidates for the office of District Surveyor was intrusted to this Institute, of which he was elected a Fellow in 1842. In 1861 he became President, and occupied the chair at intervals for two years. Re-elected in 1867, he completed his second term of office in 1870.* His official connection with the Institute was marked by great liberality. In addition to defraying the cost of the Annual Conversazione (while that expense still devolved on the President) he was the donor of several valuable prizes. He contributed £100. to the Travelling Fund, and in 1868 placed the handsome sum of £500. at the disposal of the Council for the purchase of books for the library. His late bequest of £1000., the interest of which is to be devoted to "encourage the study of Italian Architecture in England" will be fresh in the minds of our members, and is an additional instance of his generosity and of the interest which he maintained, to the last, in the objects and welfare of the Institute. In 1856 the Royal Gold Medal, annually bestowed by the Queen on some eminent architect or architectural author, nominated by the Institute, was awarded to him, and in 1869 he received from Her Majesty the more direct, but in this case hardly more coveted, honour of knighthood. On this occasion a hearty vote of congratulation was passed to him at a General Meeting of the members, and was gratefully acknowledged. His portrait, painted by J. P. Knight, R.A., hangs on the walls of the Institute Meeting Room, and was the gift of many members who were glad to pay this tribute of gratitude to one who had done so much to benefit their corporate body. The London Institution, of which he was for some years an active Honorary Secretary, possesses another portrait of him as a young man, as well as a marble bust executed by Mr. Theed, who presented a cast from it to the Institute.

In the City Sir William was well known as Chairman of the Bank of Egypt, a Director of the London and Westminster Bank, of the Globe Assurance Society, and other financial Companies. He was also a Trustee of Sir John Soane's Museum, a Magistrate for Middlesex and Westminster, and Commissioner of Lieutenancy for London. He was for many years one of the Governors of Dulwich College, and took an active part in its affairs. It may well seem extraordinary that with so much business on his hands he found time to cultivate a taste for art and letters. Yet his repute, both as a *savant* and antiquary was considerable.

---

* Mr. Tite had previously been president of the "Architectural Society," which also owed much to his generosity. This Society became incorporated with the Institute in 1842.

Sir William married in 1832 Emily, the daughter of John Curtis, Esq., of Herne Hill, Surrey, but left no children. His favourite nephew, Mr. Arthur J. Green, who was himself a very promising architect, died suddenly in December 1855, to the great grief of Sir William, who regarded him with all the affection of a father.

Among his most intimate and private friends, Sir William was very popular; and under what was considered a rather blunt manner, those who knew him best recognised a kindly heart. His ample means enabled him to subscribe liberally to many public charities, and his name is associated with the endowment of more than one institution. With all his shrewdness in business and extraordinary capacity for work, he possessed a certain vein of humour, and even enjoyed the joke of seeing his own epitaph foreshadowed in the pages of Punch about the time of his knighthood.* The latter years of Sir William's life were visited by failing health, which he sought to restore by residing, sometimes in the south of France and sometimes on the south coast of Devon. But he had meanwhile reached an advanced age, and he died at Torquay on the 20th of April, 1873. His funeral took place at Norwood a few days later, and though quietly and privately conducted, was attended by many who desired to pay a last mark of respect to his memory.

EDWARD CHARLES HAKEWILL, Fellow.

Edward Charles Hakewill who died in October 1872, was born in 1816, and was the youngest son of the late Henry Hakewill of Ulster Terrace, Regent's Park, the architect of Rugby School and other important public and private buildings. He was articled, upon the death of his father in 1830, to the late Philip Hardwick, Esq., for seven years. After serving his time, his first work as architect was Saint James' Church, Clapton, which, according to the then state of the knowledge of Gothic Architecture, was exceedingly creditable to him, and showed a zeal for the revival of church architecture which remained with him to the last. The building of this church led to that of South Hackney, the Rev. Thomas Norris being the incumbent and patron. It is a magnificent church, justly admired even in these days of church building, when the art has arrived at its highest pitch of excellence. Its plan is cruciform, with a western tower and spire in the early English style. It has a beautiful proportioned apsidal chancel groined in stone, and arcaded the whole length; the western entrance is deeply recessed, and has the figure of our Lord with St. Peter on the Sea sculptured on the tympanum.

Mr. Edward Hakewill was appointed District Surveyor to the united parishes of St. Clement Danes, St. Mary-le-Strand, and St. Paul, Covent Garden, after the death of Mr. Goldicutt. On the readjustment of districts he took that of the Hanover Square division of St. George's, which he held until his retirement from London, about five years before his death, to Playford in Suffolk, where he had built himself a house upon land purchased by him. The house is in the early English style, of the red brick of the country; it is quaint and picturesque though severe in its general treatment. Mr. Hakewill was engaged of late years in the restoration of many of the Suffolk churches, and it may be added that he undertook the work regardless of any pecuniary benefit to himself. It was painful to him to see the neglected condition of these relics of ancient architecture, and it was mainly by his influence and persuasion that so many have been restored. In 1861 he undertook the rebuilding of Rushmere Church, having previously completed the restoration of that at Wivenhoe. He subsequently executed similar works at Crowfield—a very remarkable instance of his skill—Barham, Chelmondiston, Eyke, Wickham Market, Shottisham, Kenton, Grundisburgh, Stonham Aspal, Drinkstone, Ashbocking, Beaumont and Myland. In Essex, he most successfully restored the fine Norman Church of Great Clacton; he also built the New Church of Aldham, with other churches, schools and parsonages in the neighbourhood of London and elsewhere. His memorial window is inserted in Rushmere Church, and he is buried in the adjacent and ancient church-yard of Playford, where he died October 9th, 1872. He was a competitor for the Houses of Parliament and for the Nelson Monument, the drawings for which were publicly exhibited at the time, and he was also the author of a work entitled "The Temple," an essay on the form of the Ark, the Tabernacle, and the Temple of Jerusalem.

---

* The proposed Epitaph was as follows :—

"SUARUM FORTUNARUM ET BURSÆ LONDINENSIS,
HIC JACET ARCHITECTUS, TITUS, AQUÆ CALIDENSIS,
QUI NUNQUAM DIEM PERDIDIT—SUIS SCILICET IMPENSIS."

Mr. Hakewill was a fellow of the Institute and a member of the Archæological Society, a liberal subscriber to the Architects' Benevolent and Builders' Benevolent Societies—the Church Building Society—the S. P. G. and many other institutions. He married in 1853 the daughter and heiress of the late Wm. Monkhouse, Esq.

ARTHUR S. NEWMAN, Fellow.

Arthur Shean Newman was born in 1828, at the old Bridge House, Southwark (removed in making the approach to New London Bridge). He was the son of John Newman, F.S.A., a well known antiquary and architect of many public buildings, amongst which are the School for Indigent Blind in Southwark, and the Roman Catholic Chapel in Moorfields. Arthur succeeded to his father in 1849, and was elected a fellow of the Institute in 1860, on the nomination of Professor Donaldson and other Fellows, and practised in Tooley Street, as architect and surveyor until March 3rd, 1873, when he died after a very short illness. Mr. A. S. Newman, among other appointments, held that of Surveyor to the Society of Patrons of the Charity Children's Anniversary, in which capacity he had charge of the arrangements for the annual festival of the children under the Dome of St. Paul's Cathedral. He was architect to the Deaf and Dumb Asylum and various public bodies, and was entrusted by the Committee of the Bishop of London's Fund, with the negotiations for the sites of several of the churches erected in London, he also had a large practice in compensation cases.

In 1858 he took into partnership Mr. Arthur Billing, and not long before his decease, brought his eldest son into the business, with the intention of adding him eventually to the firm.

He erected, in conjunction with his partner, a number of churches in and around London, among others the large church and schools generously built by Mr. George Moore for Somers Town, and many rectories, large warehouses, and other works in different parts of the country, one of the last being the entire restoration of the large and interesting old parish church of Stepney.

WILLIAM SLATER, Fellow.

Mr. William Slater who died on December 17th, 1872, in his fifty-fourth year, was of a Northamptonshire family, and his father lived at Haselbuck in that county. He entered the office of Mr. R. C. Carpenter at the age of 16, and during the time of his pupilage, and for many years afterwards, he resided with Mr. Carpenter and his family. About that time the 'Gothic Revival' was stirring men's minds, and Mr. Slater took his share in helping on that great movement with his friend Carpenter, one of its leaders, by assisting in working out some of his earliest designs in that style. Like Carpenter he studied deeply the principles and details of English work; and it was their great delight to make joint excursions to Northamptonshire and other churches, for the purpose of sketching and measuring those examples of Mediæval art, in days when such work was quite novel and when Continental study was attended by more difficulties than at present. To this fact probably is due the intense love Mr. Slater always had for English Gothic, while it prevented him to a great extent from indulging in the eccentricities which other eminent architects were led into through the desire of producing novelties—a desire which has been in some instances confessedly overstrained.

Between Mr. Slater and Mr. R. C. Carpenter the closest friendship existed up to the death of the latter in March 1855. Mr. Slater had been for years at the head of his friend's office, but afterwards for a short time he had taken chambers in the Adelphi, with his old fellow pupil Mr. W. Smith. However, the chief friends and clients of Mr. Carpenter (Mr. Beresford Hope, Canon Woodard, and others) held a meeting after his death, and it was determined to continue the business under Mr. Slater, both in his own interest and for the benefit of Mr. Carpenter's widow and family. Mr. Slater therefore returned to Carlton Chambers and took up the works left unfinished at his friend's death, amongst which were Lancing College, Bedgebury Park, Earl's Shilton Church, and others. He succeeded Mr. Carpenter as Architect to the Dean and Chapter of Chichester, and was then entrusted with the restoration of the Grand Choir of Sherborne Minster, by Mr. G. D. W. Digby, together with the King's School and St. John's Almshouse at Sherborne, and many neighbouring churches.

The building of the New Cathedral at Kilmore and the restoration of Limerick Cathedral were carried out under him, and also new churches at Edinburgh, Bray, Dunkeld and St. Kitt's, and the restorations of the greater part of the churches in his native county, amongst which were Higham Ferrers, Finedon, Kingsthorpe, Woodford, Easton-Maudit, Barton Latimer, Stanwick and Islip, together with many new parsonages and schools. In conjunction with Sir Gilbert Scott he carried up the new tower and spire of Chichester Cathedral, and with Professor Lewis he restored the Priory Church of St. Bartholomew the Great in Smithfield.

During all these years the most intimate friendship existed between him and Mr. Carpenter's widow and family, and it was with the greatest pleasure to both that, in 1863 Mr. R. Herbert Carpenter, who had been his pupil, became his partner—a partnership not merely one of business, but resulting from the most cordial friendship and affection.

In conjunction with Mr. R. Herbert Carpenter, Mr. Slater completed the restoration of Chichester Cathedral Choir and Hurst College Chapel, erected new churches at Bootle, Outrington, Dumfries, Belfast Church, Lawford, Southend, Milton, &c., and restored churches at Calne, Bruton, Middleton-Thornford, Thornby, Henfield-Tortworth, Earl's Barton, Tisbury, &c. Amongst other secular works were the restoration of Holdenby House, the Bishop's Palace, Chichester, Brigstock Manor House, Lord Salisbury's Mansion in Arlington Street, Seacox Heath, the seat of the Right Honourable G. J.

Goschen, M.P., works at Cheam School, Surrey, and Lancing, Denstone and Hurst Colleges, together with the Chancel and Clergy House of St. Mary, Crown Street, Soho.

Mr. Slater was always a great advocate for architects travelling as much as possible, and never in his later life missed a chance of going on the Continent; he visited the chief cities of France, Italy and Belgium, and even a few months before his death he made a tour in Switzerland in order to enjoy the glorious scenery of that country. Mr. Slater was intensely fond of music, and availed himself of every opportunity of indulging his taste for it. Indeed, it was an art eminently associated with those religious convictions which he retained through life, and which were well known to those friends whom his kindly disposition and rare simplicity of mind were justly appreciated.

SAMUEL SANDERS TEULON, Fellow.

Samuel Sanders Teulon was the eldest son of Mr. Samuel Teulon, of Greenwich, where he was born on March the 2nd, 1812. The family was of Huguenot descent, an ancester having migrated to Greenwich from Nismes, in S. France, A.D. 1685, soon after the Revocation of the Edict of Nantes.* Mr. Teulon's eventual choice of profession was strongly foreshewn in his early boyhood by a diligent aptitude for drawing, and kindred pursuits; and a studentship in the drawing school at the Royal Academy largely aided in fostering and maturing his love of art. He was first articled to Mr. George Legg, and was afterwards for some years an assistant in the office of Mr. George Porter, of Bermondsey. He commenced independent practice in the year 1838, and after some probationary experience in the execution of minor works, gained—in 1840—the first premium in a competition for some almshouses at Ball's Pond for the Dyers' Company. The erection of these buildings proved to be the nucleus of a practice thenceforth rapidly extended. During the next few years his works mainly consisted of various parish schools, parsonage houses, and the like, situate chiefly in the Home Counties. Notwithstanding the fact that his professional education had been initiated in the classic styles, his earlier designs in general shewed features of Tudor and Elizabethan character, and on the gradual advance of the Gothic Revival, he became a diligent and enthusiastic follower of its Victorian development.

The first church erected from his designs was that of St. Paul, Bermondsey, in the Early English style, built in 1846, and considered not uncreditable for that remote period, the ecclesiological enlightenment of which was as the twilight of dawn to our present noonday. Another church, that of St. Stephen, Southwark, built soon after, was adapted to a square site by being planned in the form of a Greek Cross, with the recessed angles filled in by the tower, the vestry, and the chancel aisles. Mr. Teulon had early been admitted an Associate of the Royal Institute of British Architects, and about this time became a Fellow. In the year 1849 he designed and erected at Tortworth Court, Gloucestershire, for the late Earl of Ducie, a large mansion, in an adaptation of the Tudor style. The general design and grouping of this work were considered picturesque, and the large lantern-lighted tower which rises centrally (over the principal staircases) from the main group of buildings, forms an effective feature in the *tout ensemble* of the design. He was employed at the same time in carrying out extensive improvements, farm buildings, and model cottages, on the Thorney estate, for the Duke of Bedford, and in restoring the parish churches of Pakenham, Suffolk, and Icklesham, Sussex. Soon afterwards he designed for Dr. Sumner, then Archbishop of Canterbury, Christ Church, Croydon, and the Church of St. Augustine Edgbaston, for Lord Calthorpe, whose Elizabethan mansion of Perry Hall, Staffordshire, he also restored and enlarged, and made large additions to the house at Warlies, Essex, for Sir Fowell Buxton. In his numerous designs for churches Mr. Teulon now attracted considerable notice by his original and effective treatment of brick, not only as a structural but as a chromatic and decorative material. One of his London churches which during 1855-6 received much comment and commendation on this account was that of St. Andrew, Lambeth, the most original feature in which was the reredos, with its trefoiled arches and cornice wrought wholly in brick. During 1857-60 the mansion of Shadwell Court, Norfolk, was renovated and improved for Sir R. Buxton, in a style which may be referred to the Belgian Renaissance of the XVth Century, flint and freestone were the materials employed; the original house, in Elizabethan style, was from the designs of the late Mr. Blore.

---

* Index of Names: Smiles' "Huguenots."

Mr. Teulon took a special pleasure in the execution of some works in the noble old city of Lincoln, a centre of manifold interests to lovers of ecclesiological art. Of these may be mentioned the church and rectory house at Riseholme, built for the late Bishop Kaye, in the grounds of the episcopal palace; the church of St. Michael on the Mount, and a recasting, more especially internal, of the *XVIIIth Century* church of "St. Peter at Arches," his satisfactory treatment of which latter work is said to have been the means of procuring him the honour of membership in the Ecclesiological Society, now of historical memory. During 1859 he built for Mrs. Jenkyns in memorial of her late husband, the Dean of Wells, the church of St. Thomas in that city. The parish church of St. Mary, Sunbury-on-Thames, built about 1760, in the Dark Age of our church architecture, and of the most hideous type then prevalent, was very successfully recast by Mr. Teulon in an adaptation of the Byzantine style. This work, though left incomplete externally, met with very favourable notice, and led to his appointment as architect to the Church Committee for St. Mary's, Ealing, which ultimately became perhaps the most signally successful of all his works of this kind. He carried out extensive works at Wimbledon, Surrey, the principal being a large private school for the Rev. J. M. Brackenbury, a district church and some large private residences. At the same time he designed the church of The Holy Trinity, Hastings, for the Rev. Dr. F. Crosse; the plan was adapted to fill a somewhat awkward site, at the junction of two streets, at an angle of 45°, and the work was carried out with considerable elaboration, but the tower was left unfinished. The Palace Chapel at Blenheim was ornately restored about the same time for the Duke of Marlborough. During 1860-61 large renovations and additions were carried out for Lord Calthorpe, at Elvetham, Hants, in a domestic adaptation of North Italian Gothic, and extensive works, with similar characteristics of style, were executed at Letton Court, Hereford, for the Rev. Henry Blisset. At the same time alterations and additions were made in Sandringham Hall for the Honourable Spencer Cowper, and though much of this work has been modified and recast since the purchase of the property by H.R.H. the Prince of Wales, some features of it are still retained; the church at Sandringham was also restored by Mr. Teulon. He designed, during 1860-61, a large mansion, in an adaptation of XIVth Century Gothic, for J. J. Maberly, Esq., of Hawkleyhurst, Petersfield, Hants, in which neighbourhood also, for the same client, the church at Hawkley was rebuilt in stone, after a severely simple design in the Norman style. For R. C. L. Bevan, Esq., additions to the mansion at Trent Park, Barnet, were made, also a new church parsonage and schools at Fosbury. Views of several of the principal works above mentioned, shewn in the Fine Arts' Department of the International Exhibition of 1862, procured for the architect the award of an Honourable Mention. Three other of his London churches may be referred to this period: those of St. Thomas, Agar Town, St. Mark's, Woolwich, and St. Paul's, Hampstead, the first and the last of which are noticeable as being built without aisles, but with ample breadth of nave, compensated by deep internal buttresses supporting the principal roof timbers, and arched together laterally, so that, with ample breadth for lateral sittings, the view from them eastward is as uninterrupted as from the body of the nave. In his native place, Greenwich, Mr. Teulon also erected two churches, for the Rev. G. Blisset: St. Peter's, of brick, with schools, and St. Paul's, of stone, with parsonage; the latter church is in early French Gothic, of the XIIth Century, and had to be adapted in plan to fill a triangular site. A large and successful mansion in an adaptation of XIVth Century Gothic was executed during 1863 for the Duke of St. Alban's, on his estate of Bestwood, Notts, and a church of ornate design, in the Flowing-Decorated style, was erected at Huntley, Gloucestershire, for the Rev. D. Capper, who also had a church, parsonage, and numerous estate improvements at and near Hunstanworth, Northumberland, carried out by Mr. Teulon. He was engaged, during several years, under instructions from the Office of Woods and Forests, in effecting various and extensive improvements on Her Majesty's Sunk Island Estate, and in the Park at Windsor.

During 1866, a monument of some historical interest, the Tyndale Memorial, was erected by Mr. Teulon, on Nibley Knoll, one of the highest of the Cotswold Hills; it is a square tower of simple and massive design, 120 ft. high: the great translator was a native of that part of the county. The old Church of Horsham, Sussex, was at the same time in process of very complete internal restoration; and the Church of Uley, Gloucestershire, was rebuilt; and a large domestic work in that neighbourhood carried out for T. A. Stoughton, Esquire, of Owlpen, Darsley. The Church of All Saints, Benhilton, Surrey, with parsonage and schools, was built for the late T. Alcock, Esquire, M.P. during 1867; and the Parish Church of S. Weald, Essex, was partially rebuilt and completely restored for the Rev. C. A. Belli, the vicar: the interior recasting of St. George the Martyr, Bloomsbury, was also then taken in hand for the Rev. J. Back, the rector. During 1868 the old Church of St. James, Colchester, was completely restored in accordance with the original design, which was a fine specimen of the perpendicular style; and the Church of St. John, Windsor, whose style was that considered perpendicular Gothic at the beginning of this century, underwent the process of recasting; the design for the exterior and West front, has however not yet been wholly carried out. Another recasting, of an unsightly brick church of the style prevalent in 1780, was that of the Holy Trinity Church, Leicester, where (as in St. Mary's, Ealing) Mr. Teulon introduced the feature of external ambulatories, transpiercing the deep buttresses of the aisled walls, and treated the main staircases as separate *tourelles*, flanking the west tower on either side. In the progress of the Civic improvements resulting in the Holborn Viaduct, the old Rectory House and Vestry Hall of St. Andrews, Holborn, were pulled down, and £10,000. allowed by the Commissioners for their re-erection: this was carried out by Mr. Teulon, who also superintended the interior renovation of St. Andrew's Church, for the Thavie Trustees. The more important of his later domestic buildings were, the Mansion of Westcotes, Leicester, for S. Harris, Esquire; a recasting with large additions to Branch Hill Lodge, Hampstead, and several private residences on the adjoining estate, for B. W. Smith, Esquire; and an extensive recasting with improvements, at Woodlands, Ryde, Isle of Wight, for Colonel the Honourable S. J. G. Calthorpe. Two of Mr. Teulon's most successful churches came to completion during the last active year of his life: the former, a recasting of St. Mary's, Ealing, described by Dr. Tait when Bishop of London, as "the transformation of a Georgian monstrosity into the semblance of a Byzantine Basilica;" the latter the new Church of St. Stephen's, Hampstead, a design of early French character, planned for a congregation of one thousand, and carried out mainly in Luton brick. It stands upon a slope declining eastwards, giving scope for a bold and effective treatment of the east end as an apsidal chancel, massively based upon a vaulted crypt; the tower stands centrally, and is of a type not unfamiliar in Normandy; and the west front is massively composed, its prominent feature being a broad narthex with triple archway, surmounted by a large rose-window set in the gable of the nave. The church, parsonage and schools of Allesley, Warwickshire, are memorial buildings, the erection of which, and the endowment of the living, were provided for by an accumulated bequest of £12,000.; these are mentioned as having been in progress at the time of Mr. Teulon's death; and his designs for the church of St. Nicholas, Guildford, are now being carried out under the professional superintendence of his friend and executor, Ewan Christian, Esquire. An internal recasting of the east end of St. Mark's Church, Kennington, may be pronounced his latest completed work; it was in progress during his last illness, and was formally re-opened only a week before his death, which took place at his house, Tensleys, by St. Stephen's, Hampstead, very early in the morning of May 2nd, 1873, in his sixty-second year. He had been married in 1835. Four sons and four daughters survive him.

HERBERT WILLIAMS, Fellow.

The late Mr. Herbert Williams was a man well known amongst our professional brethren in London, where he commenced his architectural career at the age of 17, as pupil of the late Mr. Samuel Angell, and afterwards assisted him in his office for some years. Commencing practice for himself about 1838, in which year he was elected a member of this Institute, he early carried out several important works at Brighton, such as the Dispensary, the Female Orphan Asylum, and the enlargement of the Sussex County Hospital. For some time he assisted the late Mr. S. Beachcroft, as District Surveyor at Chelsea, before the present system was established. In 1855 he was elected Surveyor of the Draper's Company, and subsequently executed many large buildings for them, particularly schools in London and Wales, and more recently nearly entirely rebuilt the Company's Hall in the city, a very handsome and costly building, now forming one of the finest of these civic palaces. In conjunction with our valued President, Sir Gilbert Scott, he carried out a restoration of one of the best known of the city churches, viz.: St. Michael, Cornhill, the interior of which is a fair specimen of ecclesiastical decoration. Many other buildings, particularly in the City, bear testimony to his ability and industry. He died on the 5th October last at the age of 60.

N.B.—The above biographical notices are all that the Council have been able to procure up to the present time. It is hoped that they may be supplemented by others, which will be published as soon as they have been prepared.

Royal Institute of British Architects.

At the Ordinary General Meeting held on Monday, the 18th of February, 1850, Thomas Bellamy, Vice-President, in the Chair, the following Paper was read:—

MEDIÆVAL BRICK BUILDINGS IN THE NORTH-EAST OF GERMANY, AND ON THE COAST OF THE BALTIC,

By Charles Fowler, Junr.

(*Reprinted by Order of the Council in* 1874.)

In requesting your attention to some of the examples of the Mediæval Brick Buildings which we find in the N. E. of Germany, and the adjoining coasts of the Baltic, I can hardly preface my remarks better than by laying before you the observations of one of the best authorities on the history of our art, I mean Dr. Franz Kugler, who, in reference to the buildings in question, says in his Handbook: "The *Germanic style* is developed in a peculiar manner on the coasts of the Baltic, and in some of the adjoining districts of Germany, viz., Holstein, Mecklenberg, Pomerania, the Old and New Mark Brandenberg, Prussia, Curland, Liefland, and also in the Skandinavian counties. These countries were connected and very much influenced by the confederation of the Hansa Towns, and it is probably to this influence that we may ascribe much of the similarity of style visible in the buildings of the districts referred to, though, in some instances, other circumstances may have concurred to produce many of the peculiarities which we find. The Germanic style of the Baltic countries is distinguished from that development of it which attained the greatest perfection in *Western Germany* by its greater simplicity and massiveness; though it is by no means devoid of artistic feeling, particularly in the bold proportions of the interiors, and externally in a peculiar style of ornament. It has been thought by some that the peculiarities of this style are to be accounted for entirely by the materials principally used in the construction: granite and brick, the former difficult to handle, the latter only obtainable in blocks of very small dimensions; but without wishing altogether to deny this influence of material, we shall more probably find the origin of this simple and peculiar, but effective style of architecture, in the rude but energetic character of the people by whom the monuments in question were erected. The influence of material is more decidedly visible in the decorative parts."

This peculiar style appears to extend over a considerable tract of country, but its most complete development is found in the Old Mark Brandenburg, and the principal Hansa towns, Hamburg and Lübeck.

The earliest buildings in which brick appears as the prevailing material date their commencement in the latter part of the 12th century. But it is not till the end of the 13th century that we find any examples of importance, and the style was fully developed during the 14th and down to the middle of the 15th century.

The earliest examples of this style are, as might be expected, ecclesiastical structures, and the prevailing character of these is, as we have already heard, simplicity and massiveness. The form of the plan is at first the cross, the choir having a polygonal apse with the aisle continued round it, and sometimes also small chapels spreading beyond; the floor of the choir is considerably raised, and a crypt formed under it; but the transepts were sometimes omitted, retaining the same arrangement of the choir. The best examples of this early style are to be found in the churches of Rive, Odensee, Ringstädt, Roskilde on Zeeland, and the adjoining islands.

In these examples we find the semi-arch, small windows, and many other features of the Romanesque buildings, with whom they are nearly coeval, but probably a little later. But by far the greater number of existing examples belong to a later period, as already mentioned, and these exhibit more peculiar features. The plan now presents nave and aisles only, the choir still terminates polygonally, and the aisle is sometimes continued round it; but frequently the aisles are also closed at the east end by a small apsis, and in this case the choir is continued eastward beyond the aisles; the choir is alway marked by being raised a few steps. The space between the wide projecting buttresses is sometimes occupied by small chapels, both round the east end and at the sides of the aisles. The towers are, I think, invariably placed at the west end only, and there is most commonly only one, which is embedded in the body of the church, so that the west façade is unbroken, and the tower only shews itself above the roof; in this arrangement buttresses would not have added to the apparent stability. The aisles are of equal height with the nave, or at least the vaulting springs from the same line. The roof is generally in one span over nave and aisles, rendering it a very important feature externally from its necessarily great height; the usual covering is copper. The windows are of narrow proportions, and without transoms; the tracery, where not of stone, is of a very simple and even rude character, though there are exceptions. The doorways are generally small, but deeply recessed, with rich mouldings; porches are not common, but I am able to exhibit one example from the Dom Lübeck. The form of the arches is generally about the equilateral, the pier arches more depressed. The piers are mostly of simple form, as circular or octagon, with four attached vaulting shafts; but there are examples of a more elaborate composition. The vaulting is generally the simplest form of cross vault, without any wall or ridge ribs; in each compartment, between the transverse ribs, the vault rises domically, so that there can hardly be said to be any ridge at all, as the vertical section through the centre of the vaulting would present somewhat the appearance of a series of irregular shaped domes; and, probably with a view to lighten the construction, the centre is left as an open eye, round which the moulding of the ribs is continued. In some instances the brick-work of the interior has been simply pointed, and left without any plastering or coloring except in the vaulting; this treatment, though it produces rather a gloomy effect, is perhaps preferable to the indiscriminate whitewash.

Of the Exterior the most striking feature are the towers, though usually single, and placed at the centre of the west front. They are of large dimensions, both on plan and in elevation, but of exceedingly simple outline; without buttresses, and with scarcely any ornament but the bands of sunk tracery which divide the different stories. The openings are small, too much so apparently to let out the sound of the bells; some of the smaller of these are therefore occasionally found on the outside, in a kind of balcony. The towers are most commonly square, up to the commencement of the spire, which is octagonal, and constructed of wood covered with copper or lead; the transition is made by gables on the four sides of the tower, but there are some examples where the upper part of the tower itself is octagonal.

The Spire is generally more than half the whole height, without any attempt at ornament, and terminates in a simple vane. The form is very taper, and is elegant from its simplicity; essentially different from the heavy spires of the Romanesque churches on the Rhine, which in construction they resemble.

As the Roof is generally continuous over both the nave and choir, the division is marked externally by a kind of lantern with a small spire, placed on the ridge of the roof; and this is called a Roofrider, a term very expressive of its position, though the saddle is none of the easiest.

Most of the towns of the Mark offer several examples; I shall therefore only take some of the most important with which I am acquainted. The Church of St. Mary's, Lübeck, 1250—1360, is one of the most striking; its great size, the two lofty towers, and the circumstance of its having the exceptional arrangement of a clerestory, all contribute to render it so. The extreme length inside is 340 ft., and the height of the nave 128 ft. The Briefkapelle, which is a rather later addition on the south side, is one of the most elaborate and interesting specimens of this style with which I am acquainted. The vaulting is supported by two octagon polished granite shafts, 14 in. diameter and and 38 ft. high. I will here just mention the heights of the different church towers at Lübeck, which are certainly very much beyond our usual standard.

HEIGHTS OF TOWERS.

St. Peter's	284	The Dom	391
St. Ægidus	312	St. Mary's	404
St. James	316		

English feet.

The Dom, 1174—1341, is the oldest church in the town; it has likewise two towers. Of the early part we have not much left, it is at the west end; the north porch, judging from the mouldings, cannot however be much later than 1200. The Church of St. Katherine, about 1320, has a remarkable arrangement of the choir, which forms a kind of gallery, raised on columns and vaulting, and was so disposed for the convenience of the nuns of the convent to which this church was attached. There is one other of the ecclesiastical buildings of this city which deserves particular notice; the so called *Heiligen Geist Spital* (Hospital of the Holy Ghost), founded 1234, now a church, but originally a religious establishment for the reception of the sick and wounded that returned from the Holy Land, and for sick travellers generally. The west front is very peculiar; this part of the building formed originally the chapel of the Hospital, it is now only the vestibule to the church. At Hamburg the churches have suffered more from modern alteration and destruction; the great fire in 1842 destroyed two of them, St. Peter's and St. Nicolas. Only two of the original churches now remain, and they have been much altered.

The small town of Tangermünde, on the Elbe, contains some very good examples, the Conventual Church and St. Stephen's; in the latter much of the moulded work is in stone. A short distance from this town there is a very interesting example of the early period of the brick style, in the church at Jerichow (before 1200), in which the semi-circular arch is used throughout; there is also a crypt; the cloisters which still remain show this to have been a conventual church. Not far from Tangermünde, in another direction, is situated the ancient Capital of the Mark Brandenburg, Stenthal, where there are several fine churches of the brick style (the Dom, St. Mary's, St. James', and St. Peter's) all on a very large scale. At Brandenburg the Dom affords another example of the earlier period, at least in part. The Church of St. Katharine, (1401), partakes externally rather of the civil than ecclesiastical character; the façade has a stepped gable. I will only mention further the Church of St. Nicolas, at Stralsund, (begun 1311), and that of St. Mary, at Stargard, in Pomerania, both of which are stated to be particularly fine examples of the style.

We will now turn to the *Civil Architecture* of the brick style, examples of which do not occur till about the latter part of the fourteenth century, and they are generally of a much more elaborate character, with greater sub-division of parts, and more profuse decoration. Among these buildings the Town Halls or Senate Houses form an important class, but they will hardly admit of any general description; further the Gate Towers and other fortifications are very worthy of notice; and lastly the private houses, though these do not offer any very great variety. We will therefore proceed at once to examine some of the examples.

The Senate House at Lübeck is perhaps the most important of its class, as that town was at the head of the Hansa Confederation, and the Delegates from the different cities met in the Senate House there, which is therefore much larger than would have been necessary for the purposes of the Town Council alone. The erection of this building spreads over a considerable period, down as late as the beginning of the sixteenth century, but the most interesting portion is that first erected. It consists of an open arcade, on granite piers on the ground floor, probably for the use of the market, over which were the halls, &c., lighted by large windows. The roof is masked by a row of turrets, connected by a kind of arcade, which gives a peculiar character to the building.

The Town Hall at Tangermünde is an example of a different class; the most remarkable feature is the gable end, richly decorated with octagon buttresses, having stories of canopied niches—the gable is stepped between these buttresses. Altogether it strongly resembles the façade of the Church of St. Katharine, at Brandenburg, and dates probably from the same period, the beginning of the 15th century.

The Hall of Justice (as it is called) at Brandenburg, presents a somewhat different arrangement; it is by no means so fine an example as that last mentioned. The arrangement of the centre of the front is very peculiar; there is elaborate tracery at the heads of the door and windows, and this, if coeval with the rest of the building, would assign a late date for its erection.

Having before alluded to Stralsund, I will here mention that the Town Hall there (built 1316) is spoken of as having seven towers, most probably somewhat in the manner of that of Lübeck. There are numerous other examples, which appear mostly to date from the fourteenth and beginning of the fifteenth centuries.

Many towns of the district we are considering appear to have been fortified by a continuous wall, generally of brick-work with turrets at intervals, and with large gate towers, both single and double. Very fine examples of the latter are found at Lübeck, but the enceinte appears in this case to have been an earth-work, though not that now existing. These towers were without doubt originally crowned with battlements, as is still the case in some other examples; but even as they now are they form imposing entrances to the town. The date of these buildings would appear to fall in the middle of the fifteenth century. At Tangermünde the wall is of brick, and remains almost perfect, and there are also some fine gate towers. At Stenthal we find two good examples of this class of building, at Brandenburg several, and many others.

But I must pass on to another class of examples—the private buildings, of which I find the following description in an old chronicle of the town of Lübeck: "on one or both sides of the lofty door there is a sitting room, and at the back a small bed room, over the former the business room; it was some time before any other window was introduced. Besides that common to the sitting and business rooms, the hall for the goods and the several stories in the roof had only wooden shutters." This description is of the houses of the fourteenth century, but with very slight alterations it would embrace the greater part of the town at this day.

In 1209 the town of Lübeck was nearly destroyed by fire, and previous to this period the private buildings were probably entirely constructed of wood, as after the fire it appears the senate passed a *Building Act*, which ordered that at least both the gable ends of private houses should be of brick. The principal feature of the private buildings are the stepped gables, which are sometimes of great height, and of which every possible variety is met with. They are decorated with long strips of panels, arch-headed, and divided into stories of niches and openings; these panels are never continued down over the lower part of the house, where the openings have frequently quite a different arrangement. The steps of the gables are very bold, giving a peculiar picturesque character not met with in similar buildings elsewhere. Most of the openings of windows and doors have the segmental arch, being more manageable than the pointed form which is given to those of the niches or panels.

The treatment of the *ornamental* parts in this style is peculiar and well adapted to the material in which they are executed. There is one feature in particular which deserves attention, I mean the introduction of a white plastered ground to relieve the forms of tracery, &c. put over it. This relief by *color* is rendered necessary by the *dark* hue of the material, owing to which the *shadow* of small projections would not give sufficient relief.

In the early examples of the brick style, the more elaborate parts, including the tracery of the windows and other moulded work, were executed in stone. Horizontal bands of stone were also occasionally introduced, and they have a good effect in tying together the different parts of the composition, besides their value in a constructive point of view. But in the later examples from the end of the fourteenth century, stone is entirely dispensed with, and we find even such parts as crockets and finials executed *in brick.* The use of dark brown or black glazed bricks was also common during the later period. The character of the mouldings varies of course somewhat in the different periods, being simpler in the earlier, and more elaborately subdivided in the later; delicacy of profile can hardly be expected from the nature of the material. Moulded bricks were also used to make up general forms, such as circular piers, the inner side of circular turrets, &c.

There are a few points in the construction of the buildings we have been examining which ought not to be passed over. There is usually a granite plinth carried all round the churches, and the towers are faced with the same several feet up. The absence of buttresses to the towers rendered it necessary to increase the thickness of the walls, which we find is very considerable, notwithstanding which they mostly incline from the upright, and it is remarkable that this occurs most frequently towards the S.W. While speaking of the mortar joints, I should mention that they are invariably very wide (from ½ in. to ¾ in. or even more)—the mortar itself is extremely hard, and the lime used was, for the district we are considering, principally supplied from Segeberg in Holstein.

The construction of the *vaulting,* I think, claims particular attention; in the first place, a light material was prepared in bricks, moulded of a wedge form. The ribs seem to have been first constructed, independently, as a skeleton, and between them the spandrils were filled in with the light bricks, apparently without the use of centering, as each spandril is considerably arched up to enable it to support its own or any super-incumbent weight; thus the vaulting rests entirely on the ribs which are not tailed into it. It is a single brick in thickness, about 6 in., and is backed-up only a very short distance above the springing, so that the form is very distinctly seen on the upper surface, where it presents a very remarkable appearance. The bond used throughout is the Flemish, or as it is there called cross-bond; the arches are always built in half-brick rings.

The bricks used in the buildings I have brought under your notice are of a larger size than those now commonly used in the district; they are remarkably hard and sound, and are rather heavy; though externally of a brown red colour, the inside is grey, like our stocks; this is not the case with those now made. The light vaulting bricks were made with a mixture of chopped straw, so that when burnt they were porous, but of sufficient strength for their purpose. I have discovered no examples of guaged work.—The first-class bricks, as a material, are superior to those used in this country: the colour uniformly red, except where a vitreous action had been produced in the burning. There did not appear to have been a rubbing down of the face of the material when used for mullious or tracery—the ordinary examples presented too rude a surface to suppose such an operation. The brick was shaped, when it was half dried, or rather the bricks were cut for ornamental purposes before they were burned.

Mr. Smirke said that he had recently been much interested in a cursory inspection of some examples of old brick-work in Germany. At Hanover and Hamburgh there are Churches constructed of brick, with windows having deeply moulded jambs, and slender mullions of considerable height, wholly of that material. He thought that these instances might be adduced in corroboration of a remark he had made here on a former occasion, that we are in England scarcely aware of the great capabilities of terra cotta. The application of burnt clay to the purposes of ornamental architecture seems to have been carried farthest in flat alluvial countries, as on the eastern side of England and in western Germany, where of course good building stone does not occur, and where the expense and difficulty of transit in former times encouraged the use of artificial materials. In Norfolk and Suffolk, and the adjacent counties, many examples remain of delicate ornamental brick-work. In parts of Germany this fabric is at the present day far better understood than with us. The Bauschule at Berlin is a most remarkable specimen of Schinkel's genius: it is a building of very great extent, and of most elaborate detail, entirely executed in brick-work, unrelieved by any portion of stone. Its dark red color gives to the building a somewhat heavy general effect, very similar to the red sand-stone so much used in some parts of England, but on a close inspection one is surprised at the fineness and delicacy of the details. Throughout western Germany bricks are worked with a fantastic ingenuity rarely visible with us: by the use of various coloured bricks intermixed, an ornamental character is given to the commonest buildings, somewhat whimsical perhaps to our plain English eyes, but yet well deserving observation.

Mr. Fowler, sen., had been struck when abroad with the curious specimens of brick-work which he met with, particularly the Old Rathhaus, Hanover. Schinkel's remarkable building at Berlin, whatever might be its merits architecturally, was a striking example of what might be done in brick-work or terra cotta. The whole of that immense structure was of that material, and it was certainly executed in a very extraordinary manner. It was by no means striking in its outline. He would not have ventured to say that in Berlin, where the worth of Schinkel's works must not be doubted, but he would assert here, that as a piece of architecture it possessed no great merit. It did far greater credit to the person who executed the work; for the able manner in which the details were carried out was surprising, and served to show, beyond what he would have conceived possible, the capability of brick as a material. These examples in stricter phrase related to terra cotta rather than to vulgar brick.

Mr. Bellamy (the Chairman) remarked that Mr. Sharpe of Lancaster had introduced terra cotta to a great extent in the construction of Churches, and with considerable effect. There was however at the present time rather an affectation in the application of brick-work, which it was not desirable to encourage. He had seen instances in which the cost of ornamental construction in brick had exceeded that of stone; whilst, notwithstanding the beautiful effect sometimes produced by a judicious combination of the two materials, it must be admitted to fall short of that obtainable in stone. The practical objection to the combination of rubbed and gauged bricks with the ordinary building brick, by which bond is interrupted and not recovered for several courses, should not be lost sight of in adopting that material.

Mr. Donaldson considered that the absence of buttresses, alluded to by the Lecturer, on the external faces of these brick edifices materially detracted from their effect. These massive buildings rising up with the landscape, possessed great nobleness in point of mass, but at the same time they exhibited great want of taste. High as their spires rose and imposing as were their dimensions, they were remarkable for a want of chiaro-scuro and contrast, which marred their appearance as works of art. The influence of Flemish taste in our brick-work was perceptible in many examples of past times, which might be accounted for by the fact, that the Flemish builders were brought over to execute brick constructions similar to their own. But in this country brick-work, as applied to Gothic detail, had never been carried to the same extent as in the low countries. Our travellers abroad had not so much noticed, as they deserved, the edifices to which attention had been drawn by Mr. Fowler, for the surface of many had been colored over with a light tint, and they appeared to persons passing through those towns as though they were of stone, instead of being of brick construction.

A vote of thanks was then passed unanimously to Mr. Chas. Fowler, for his interesting communication, and for the able drawings with which it was illustrated.

GETTY CENTER LIBRARY
3 3125 00614 6431